

ENVIRONMENTAL STANDARDS

A Comparative Study of Canadian
Standards, Standard Setting
Processes and Enforcement





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HOW ADEQUATE ARE ALBERTA'S STANDARDS ?

Ambient Air Quality

The Canadian Federal efforts in the setting of ambient air quality standards have significantly influenced the standards set by the provinces. Alberta is no exception. It has adopted the Canadian Federal "desirable" level for particulates, carbon monoxide, oxides of nitrogen (annual average), and sulphur dioxide, and the Canadian Federal acceptable level for oxides of nitrogen (24- and 1-hour) and oxidants (ozone). The province is therefore well within the generally accepted practice of Canadian standards-setting bodies. However, a standard for hydrocarbons is not included by any of the Canadian jurisdictions and, because it is important in the formation of photochemical smog, the establishment of a standard for this parameter should be considered.

Ambient Water Quality

On the whole, Alberta's standards for ambient water are quite similar to those of other jurisdictions. There are, however, a few areas that could be examined further by the regulatory authority.

1. Alberta and Saskatchewan have jointly developed standards that are intended to protect all potential water uses, including aquatic life, which is often the most sensitive. However, in several cases (cadmium, copper, lead, and silver), these general standards are considerably more lenient than the specific standards for aquatic life set by Ontario and the Canadian Federal government. The same is true for cyanide, sulphide, and phenolics. The stricter standards prevailing in these other jurisdictions should

* There is no agreement in the literature concerning a definition for the word "standard". We have used the word in its general sense to denote a set of prescribed numerical values to which contaminant concentrations may be compared, whether they are legally enforceable or not. A more thorough discussion of terminology is included in Chapter 2 of this report.

be examined to see if there is reason to upgrade the Alberta standards. Another toxic substance, omitted altogether from Alberta's standards, is residual chlorine.

2. Another approach to pesticide regulation may be appropriate. Alberta and Saskatchewan presently specify only the generalized standard of 1% of the 48-hour median tolerance limit. The scarcity of information on tolerance limits and the focus solely on lethal effects are shortcomings of this approach, which are discussed more fully in the text. Specific concentrations of specific substances may be a more desirable type of standard.
3. Alberta's standards cover only surface waters. In a province where well injection of wastes is practiced and water is often abstracted for domestic and other uses, it may be appropriate to extend applicability of surface water standards to groundwater or to develop a set of standards for the latter.

Airborne Effluents

Alberta has special standards only for the fertilizer, vinyl chloride, natural gas-processing, and secondary lead smelting industries. In the other cases studied, only the two effluent parameters (opacity and particulates) for all emitters specified in the Clean Air (Maximum Levels) Regulations are available for guidance on effluent quality requirements. The province could choose one of several approaches for filling this gap: standards could be developed for other industries similar to those published for the fertilizer industry, which appear thorough and informative, or the Clean Air Regulations could be expanded to include other effluent quality parameters.

Waterborne Effluents

No standards for effluent quality for the chlor-alkali and pulp and paper industries have been developed. More puzzling, however, is the absence of standards for the effluents of municipal wastewater treatment plants. While the specification of type of treatment and the performance required of a completed plant may be taken care of through the permit process, it is desirable that the principles governing such decisions be formulated in a general way. British Columbia's complete standard format may be an interesting model to study, because it bases the expectations on both the wastewater volume and

the dilution available in the receiving water, and is thus, in a limited way, site-specific.

On the whole, Alberta's effluent standards values appear to be of comparable stringency to those of other jurisdictions.

An extensive summary of Chapters 2-7 of the Report follows.

CHAPTER 2. A MODEL PROCEDURE FOR SETTING ENVIRONMENTAL STANDARDS

The setting of standards consists of a number of processes in which both technical and socio-political variables are considered and evaluated. These processes may be summarized as follows:

1. Formulation of objectives. This consists of definition and selection of the goals of regulatory effort, in particular, deciding what uses of the air or water resource are to be protected and with what degree of certainty. This necessitates information on public preferences.
2. Selection of criteria. This consists of the gathering and compiling of relevant data on the effects of various pollutants and/or levels of resource quality on the protected uses, and the evaluation of the data to identify the levels offering various degrees of protection.
3. Establishment of ambient standards. Ambient standards, that is, standards for the quality of the air or water resource, are a product of both the technical considerations involved in arriving at criteria and the nontechnical considerations of economics, political acceptability, etc., that govern the level of safety factors and degree of certainty of protection.
4. Establishment of effluent standards. This again involves both technical and nontechnical elements. Technical knowledge must be brought to bear on the relationship of the quality of effluent to the quality of the receiving resource, and on possible means of achieving the effluent qualities desired. The economics of pollution control

and the political considerations of who pays for control efforts and how, are important nontechnical considerations.

5. Monitoring and enforcement. Monitoring of ambient conditions provides information on how well objectives are being met, while monitoring of effluents shows whether or not the effluent levels selected are actually conducive to the desired ambient quality, as well as whether the various dischargers are meeting the responsibilities imposed on them. The latter information is necessary in enforcement efforts.

Before discussing how standards are set and enforced in Canada it is worthwhile to clarify the meaning of the term "standards" as used in this study. We use the term in the ordinary, everyday sense of an accepted norm of conduct. Often lawyers and enforcement officials restrict the term "standard" to only those limitations that are legally enforceable. We have avoided this restricted definition because it would eliminate most environmental norms that have been promulgated in Canada. This is not to suggest that these norms or "standards", as we shall call them, are not enforceable in the broad sense. They often are used as guidelines when limitations are developed for inclusion in legally enforceable permits and licences.

While all of the regulatory approaches encountered in this study include some of the elements listed above, none follow this idealized model completely.

CHAPTER 3. LEGISLATION AND GUIDELINES

Legislation in the study provinces establishes systems for permitting discharge of contaminants into water or air. Ontario and British Columbia also regulate discharges to land by means of permits. Terms and conditions may be attached to permits by the issuing authorities. There are no Federal permits, but informal "compliance schedules" are negotiated by Federal officials under the Fisheries Act and its regulations and guidelines.

Failure to obtain a permit or to comply with the terms and conditions of a permit is an offence. By this means, otherwise unenforceable standards are made enforceable by incorporation in permits. This is important because a significant majority

of standards, both ambient and emission, are not directly enforceable, even if they are included in regulations.

Only the Federal water effluent standards under the Fisheries Act regulations, Ontario's point-of-impingement air quality standards, and Saskatchewan's ambient air standards are directly enforceable. However, all jurisdictions have general pollution offences aimed at discharge of "waste", "contaminants", or "deleterious substances". These terms are defined with reference to adverse effects on human health or comfort, vegetation, property, or fish and wildlife. Thus they are rather imprecise but nevertheless legally enforceable standards.

CHAPTER 4. THE STANDARD SETTING PROCESS

The process of setting ambient and emission standards is described for each study jurisdiction. Ontario's Environmental Air Standards Setting Committee represents the most elaborate administrative and procedural standard setting technique identified. However, no jurisdiction has a standard setting system that completely accords with the "model" described in Chapter 2.

Generally, goals and objectives upon which standards are based are not clearly articulated. Ontario's ambient water quality "Blue Book" is the most explicit in stating goals that ambient standards are intended to achieve. A major reason for this lack of goal clarity is that all jurisdictions tend to run together the goal identification, criteria development, and ambient standard specification steps in the standard setting process. This has the effect of obscuring the value judgments involved in goal and objective determination and emphasizing the scientific and technical aspects of the process.

Nor is the judgmental aspect of ambient standard specification made clear in any of the study jurisdictions. Factors such as safety may compel establishment of an ambient standard that is stricter than that dictated by criteria alone.

The Federal-Provincial committees that established the Federal National Ambient Air Quality Objectives have had a substantial influence on provincial ambient air standards. So have the Federal-Provincial-industry task forces that established

liquid effluent standards for incorporation in the Fisheries Act regulations.

Alberta and the Federal government have established air emission and water effluent standards for major industries by means of government-industry task forces. British Columbia has developed industry standards through a public inquiry process that involves industry and other public interests. All study jurisdictions tend to link ambient and emission standards, although this is not completely uniform.

Saskatchewan, with only a small number of plants in each category, has not found industry standards necessary and proceeds on the basis of case-by-case evaluation. When, as in the case of air quality standards for potash facilities, Saskatchewan has considered it appropriate to develop standards for an industry, it has also adopted the government-industry task force approach.

Ontario has no industry standards for a different reason. The southern part of the province is relatively heavily industrialized. There is often little unused air or water receiving capacity in particular areas. Therefore, since maintenance of ambient limits often requires firm contaminant concentration limitations, province-wide emission standards are used for both air and water regardless of source. In less heavily industrialized provinces with more favourable ambient conditions, such as Alberta, total waste loading is a greater concern. This latter focus suggests an approach that emphasizes regulation of industries so that attention can be given to plant design and processes.

Permits and licences are handled on a case-by-case basis in all jurisdictions where unenforceable standards, either in the form of regulation values or guidelines or objectives exist. These unenforceable standards tend either to be incorporated into permits as a matter of course, or to be regarded as compliance preconditions for granting permits. However, negotiation is an important aspect of permitting so that unenforceable standards may be departed from on the basis of technical or economic considerations, or a compliance time frame may be agreed upon.

Content of permits varies considerably, from the detailed Alberta permits containing both ambient and emission values, to the brief Ontario certificates that reflect, but do not incorporate, application documents and negotiated abatement requirements. Monitoring requirements on permittees are a

feature of all permits reviewed. However, detail of monitoring requirements varies. Some permit conditions either give broad discretion to government officials, or are simply vague or ambiguous.

Generally, the process of standard setting is treated as a technical process by government and industry. The public appears to have largely accepted this view as well. However, social, economic and political factors are usually more significant than technical and scientific factors. Consequently, we have government-industry and Federal-Provincial standard setting task forces and negotiation in permitting. This non-technical aspect is clearly recognized by government officials involved in the process, but it is not well known to the public. Consequently there has been relatively little pressure for public participation in setting standards in any of the study jurisdictions, with the possible exception of Ontario.

Public participation has not been a feature of standard setting in any of the study jurisdictions except British Columbia. The British Columbia process has been criticized as overly formal and technically-oriented, and it is not clear that it will continue after the legislative overhaul currently in progress. A policy that requires notice and opportunity for public input on significant new regulations and guidelines is now being implemented by Environment Canada.

In our view, public participation should be an essential part of standard setting. It reinforces accountability of the standard setters, given the significant value judgments involved. And it provides direct guidance and support for public servants faced with value judgments that may involve human health or even human life trade-offs. Effective public participation is likely to enhance public understanding of risks and trade-off factors involved in establishing environmental standards. It should increase public understanding and appreciation of enforcement problems. For example, better public understanding of the statistical nature of ambient values, given the difficulty of identifying "worst cases", may assist enforcement officers in their efforts to achieve compliance without prosecuting every ambient standard breach.

If compliance is largely negotiated as a result of the practical and conceptual difficulties with prosecutions, then public participation is a necessary counterweight. Government officials will be supported and generally kept "honest" in compliance negotiations if public input is permitted at

appropriate stages. The public is less likely to harbour suspicions that government and industry are colluding to the detriment of human health and environment quality.

CHAPTER 5. COMPARISON OF AMBIENT STANDARDS

Ambient standards for air and water quality have been identified, where they exist, for all the study jurisdictions.

The major air pollutants identified are particulates, dustfall, carbon monoxide, hydrogen sulphide, sulphur dioxide, oxides of nitrogen, and oxidants (ozone). Consideration of the sources of these pollutants indicates that a large quantity come from transportation activities, notably the automobile. Because none of the case studies focuses on transportation, its importance must be mentioned here.

All ambient air standards are set with respect to specific time periods. This allows short-term incidents of higher pollutant levels, caused by atmospheric conditions, that do not substantially influence the long-range quality level. Some jurisdictions have several levels of standards. The Canadian Federal government, for example, has "maximum desirable", "maximum acceptable", and "maximum tolerable" levels for certain pollutants. The most striking observation of this segment of our study is the very great influence that Canadian Federal limits have on the limits set by the provinces. Federal desirable and acceptable levels are adopted or closely approximated by most of the provinces for most of the parameters. In general, these standards compare quite favourably with those promulgated by the United States Federal government, being in most cases at least as stringent.

Numerous pollutants have been identified in water quality standards. These are categorized as physical, chemical (metals, inorganic nonmetals, and organics), radioactive, and microbiological. Many of the standards studied are aimed at protection of specific uses, such as domestic water supply, protection of aquatic life, irrigation, and contact recreation. Others, however, are general and are intended to protect all potential uses. Some of the standards are given in terms of permissible change from natural or background conditions, although most are in terms of limiting concentration. The

numbers of parameters covered and the detail with which they are covered varies from jurisdiction to jurisdiction.

The greatest degree of uniformity is in the standards for drinking water. Where water standards are given separately for different uses, those for protection of aquatic life are generally the most stringent. The general standards adopted by Alberta and Saskatchewan for certain variables do not appear to be as strict as special standards for aquatic life in other jurisdictions. Re-examination of these limits may be desirable.

CHAPTER 6. EFFLUENT LIMITATIONS FOR CASE-STUDY INDUSTRIES

Comparisons of air and water effluent standards were made for the case study industries and activities. British Columbia has established various control levels, as has the United States. For air emissions, Ontario is unique in having point-of-impingement standards, which specify not the pollutant concentration at the point of emission, but rather at the point where the emission comes in contact with some structure or other point of impingement. Mathematical formulas are given to calculate the point of impingement value from the rate of pollutant emission for various configurations. These standards are therefore not directly comparable to those of other jurisdictions.

British Columbia is the only Canadian jurisdiction having special airborne emission standards for the petroleum industry. The United States also has such standards, and they are in general more stringent than those of British Columbia. All the jurisdictions studied have standards governing waterborne emissions from the petroleum industry. With the exception of those of British Columbia, all are expressed as amount of pollutant per unit of refinery production. Ontario has adopted the Canadian Federal limits where these are more stringent than Ontario's general limits applicable to all industries. Alberta's standards also parallel the Canadian Federal limits for new refineries in cases where the Alberta refineries do not have injection well disposal systems. Alberta's limits for refineries with disposal wells are more stringent. Most Canadian standards are similar to the United States best practicable technology limits.

Three types of chemical industry were studied: the chlor-alkali industry, the fertilizer manufacturing industry, and

the vinyl chloride industry. Only British Columbia has extensive standards for airborne emissions from the chlor-alkali industry, although the Canadian Federal government and the United States have standards for mercury emissions. Of these, the Canadian Federal standard is the most stringent.

Alberta, British Columbia, and the United States have specific standards for the fertilizer industry's airborne emissions. Emissions of sulphur-containing compounds and fluorides are the primary concerns. Alberta's standards are nearly identical to those of the United States, and British Columbia's are generally of similar magnitude. The standards established for airborne emissions from the vinyl chloride industry in Alberta, Canada (Federal), and the United States are identical.

With respect to waterborne emissions from the chlor-alkali industry, mercury is again the chief concern. The Canadian Federal standard appears to be the most lenient. Ontario's general industrial standard is approximately equal to that set by the United States.

Alberta, British Columbia, and the United States have specific standards governing waterborne emissions from the fertilizer industry, and Ontario has its general standard. The stringency of these varies for the different parameters.

Alberta and British Columbia have important natural gas industries and have established standards for air and waterborne effluents from natural gas processing plants. The standards for airborne emissions take the form of minimum requirements for removal of sulphur. These are over 90 percent in almost all cases, depending on gas quality and plant size, and 99 percent in certain cases.

Comparison of the standards for waterborne emissions indicates that those of Alberta are somewhat less stringent than those of British Columbia for most conventional parameters, but that Alberta has quite strict requirements for mercury emissions and toxicity of the effluent.

The study of pulp mill standards was limited to the kraft (sulphate) process. For airborne emissions, British Columbia, the Canadian Federal government, and the United States have established specific standards and Ontario has adopted the Canadian Federal standards. All seem to be in substantial accord on the values for sulphur-containing compounds, which are of greatest concern.

The same jurisdictions have standards for waterborne emissions. In this case, the Canadian Federal limits appear to be particularly stringent for suspended solids and particularly permissive with respect to oxygen-demanding substances.

The requirements for municipal wastewater treatment vary greatly in form. British Columbia, Saskatchewan, and the United States have some form of standard, British Columbia's being quite detailed about the level of control for specific types of waterways and available dilutions. While Ontario does not have specific standards for this activity, it is understood to apply to municipal effluents the same requirements for suspended solids and biochemical oxygen demand applied to industrial effluents, that is, it essentially calls for an effluent equivalent to that of a well-operated secondary treatment plant (15 mg/l BOD, 15 mg/l suspended solids). Alberta and the Federal government do not appear to have standards for this activity. British Columbia's standards call for the equivalent of secondary treatment for discharges to lakes and to flowing waters where limited dilution is available, and for primary treatment elsewhere. Saskatchewan gives expected effluent values for primary and secondary treatment, but no guidance as to which may be required under given circumstances. The United States requires secondary treatment as a general rule.

Municipal solid waste disposal is the subject of various regulations in the study jurisdictions. Both landfill and incineration are considered. Alberta, British Columbia, Ontario, and Saskatchewan all have regulations covering landfill-type operations, and these have many similarities with respect to location restrictions and frequency and depth of cover. For incineration, Alberta, British Columbia, and the United States have similar requirements for particulate emissions. British Columbia and the Canadian Federal government have identical sulphur dioxide limits; Alberta does not have a standard for this parameter.

Airborne emissions from coal-fired electrical generating plants are the subject of regulation in British Columbia, Canada (Federal), and the United States. Alberta covers particulate emissions in its general air emission regulation. The United States Federal government appears to have the most stringent standard for particulates, followed by that of Canada. The Canadian standard for the very important parameter of sulphur dioxide, although not formulated in the same way as the United States standard, is in general somewhat more stringent.

CHAPTER 7. ENFORCEMENT OF ENVIRONMENTAL STANDARDS

When most people think of enforcement of a law they think of a process that begins with detection of a violation and ends with a prosecution. Most statutory schemes of environmental control are based on this model. However, the objective of enforcement activity is compliance with the standards, and there are other ways of pursuing this objective. Negotiation and moral suasion, perhaps backed up with the threat of prosecution, can also be effective and are often used by governmental authorities. In fact, prosecutions may not be very effective, as the following discussion indicates.

Several difficulties are encountered in the traditional prosecution-oriented enforcement process. One of the most obvious is the so-called "due diligence" defence. Polluters may defend against prosecution under environmental legislation by showing that they were reasonably diligent in trying to comply with standards. The courts have created this defence to protect individuals against the risk of being stigmatized by criminal convictions when they are not morally at fault, in the common sense of the word. It is argued in this report that the defence should not be applied to situations in which there is non-compliance with the terms of a permit or licence. The defence is inconsistent, in legal theory, with the concept of a permit or licence. In essence, when government issues a licence to a discharger it is giving the discharger permission to operate as long as the terms of the permit or licence are not violated. It should not matter whether the reasons for non-compliance are ones that involve fault or ones for which the permittee is blameless, in the criminal law sense. The risk of non-compliance with the permit should be on the permittee, not the public. Nonetheless, at this time due diligence is a defence under most environmental legislation, and prosecutors and other enforcement officials assert that this defence makes it difficult to prosecute for non-compliance with environmental standards.

Other factors inhibit enforcement. One is the burden of proof required in criminal proceedings. In order to protect individuals the criminal process is weighted in favour of the accused, and a high standard of proof is required. Facts must be proved beyond reasonable doubt. When monitoring data and testing results are involved this can pose difficulties. In one case, for example, a court held that mathematical interpolation of meter readings did not satisfy the burden of proof. It is possible for officials to meet the high criminal standard of proof, but it is an inhibiting factor. A second inhibiting factor appears to be a general inadequacy of fines. Many officials feel that the fines actually imposed

in environmental offences are so low that it is hardly worthwhile prosecuting offenders.

Because of these difficulties, and perhaps for other reasons, officials often tend to negotiate with polluters rather than prosecuting them. The purpose of negotiating is clearly, from a public point of view, to establish some program of action that will result in abating pollution. Many officials feel that this strategy is far more effective than a strategy of prosecuting dischargers automatically whenever they are in non-compliance with environmental standards. On the other hand, some commentators are highly critical of this policy and assert that it tends to cause disrespect for environmental law. We also note that it does lead the interested public to be cynical about environmental enforcement.

We believe that negotiation has a role to play in enforcement policy. One can easily imagine situations where prosecutions would be undesirable. Consider the example of a standard that has been based on erroneous information about the effectiveness of available abatement technologies. After the government has induced a firm to spend thousands of dollars on equipment that does not do the job, wouldn't it be unfair for government to insist rigidly that there must be immediate compliance with the standard? The better approach here would be to re-examine the situation and negotiate a new abatement program. But, while negotiation may be desirable in such a case, it must be remembered that the public will not easily understand why environmental standards are not being enforced. Unless the need for leniency is explained publicly, there is likely to be an adverse reaction to non-enforcement. Governments have not been very candid about these problems, and the result has been an unhealthy cynicism about governments' resolve to enforce environmental standards.

Many of the enforcement problems outlined above seem to be symptomatic of a larger problem - the inappropriateness of the criminal law approach to the enforcement, or perhaps we should say implementation, of environmental standards. The due diligence defence, the high standard of proof, the concern about whether it is appropriate to negotiate concerning non-compliance all relate in some way to special concerns of the criminal law. Special deals are inappropriate where criminal sanctions are involved. This creates a real conflict for officials responsible for the enforcement of environmental standards, because most legally enforceable environmental standards are site- and industry-specific.

Several of the provinces studied are experimenting with different ways of dealing with non-compliance, in order to avoid the problems outlined above. In Ontario and British Columbia special task forces have been used for investigation and enforcement. This approach allows government to create special training programs and allows enforcement officials to acquire the expertise necessary for dealing with the special problems of the criminal law. Ontario also relies more heavily on the control order than it has in the past. Rather than prosecute for non-compliance with the terms of a permit or licence, a control order is issued to the discharger. Then, if that is not complied with, the polluter can be prosecuted for non-compliance with the control order. This approach effectively makes it hard for the polluter to rely on the due diligence defence because the enforcement officials have spelled out precisely what is required in the order.

Curiously, it is very difficult to tell how well environmental standards are being complied with. If these standards represent our goals with respect to the environment, one would think that clear statements would be issued from time to time telling anyone who is interested how we are doing. It is not generally done. There are a few reports dealing with specific Federal standards, and technical reports are published summarizing various monitoring data, but these tend to be highly technical. Rarely are they understandable by a reasonably well informed layman. Moreover, the public has very little access to the enforcement process itself. Officials tend to be reluctant to discuss non-compliance. Their reasons are easy to understand. Premature release of information might prejudice an on-going investigation, and once a prosecution is commenced the matter is said to be "sub judice" and should not be discussed further.

We feel that this lack of public information about the enforcement process creates a severe credibility gap for environmental law. If the difficulties of enforcement are not explained, if data on compliance are hard to locate, and if officials are seen to negotiate with polluters rather than prosecute them, the public will tend to believe the worst - that government is not committed to the enforcement of environmental standards.

After our review, we do not know how well environmental standards are being enforced. We do know that there are public officials who are committed to enforcement, in the broad sense of that word. And we know that they encounter difficulties, but seem to be experimenting with new ways of dealing with those difficulties. But we also observe a lot of public criticism. Many observers seem to feel that government is not making a

serious effort. We feel that an information gap may be responsible for this lack of public confidence, and recommend that a greater effort be made to explain the enforcement process to the public and to document its successes.



Chapters One to Seven



CHAPTER 1

INTRODUCTION

Environmental standards have often been the subject of controversy. Standards for particular contaminants have been characterized as unrealistic by industry and as inadequate by public interest groups. Similarly, divergent views of enforcement of standards have been taken by various interests. Standards in certain jurisdictions have been perceived as weaker or stronger than those in others.

This study addresses these issues. It identifies and tabulates ambient and emission standards for air and water in British Columbia, Alberta, Saskatchewan, Ontario, and the Canadian and United States Federal governments. Standards that exist for disposal of contaminants to land are also identified. The legislative context for environmental standards in each jurisdiction is outlined. Standards are then standardized to the extent possible, and compared to show variations between jurisdictions and the overall picture for major contaminant standards in particular jurisdictions. For emission standards this comparison is done in relation to seven case study industries, namely: petroleum refineries, chemical plants (chlor alkali, vinyl chloride, and fertilizer), natural gas processing plants, pulp and paper mills, municipal sewage treatment plants, municipal solid waste disposal sites, and coal-fired electric generating plants.

It was expected that significant differences would be apparent after all of the standards were tabulated, and that these could be evaluated easily. This did not prove to be the case. Instead, one is struck by the basic similarity of the environmental standards in the study jurisdictions. Differences do exist, of course, but these seem subtle, and evaluation of them within the scope of this study proved impossible. There are too many minor variations in the standards, and too many complex factors to evaluate in the different industries and jurisdictions studied. For example, the dustfall limitation for non-residential areas in Alberta is 45 tons per square mile per month and in British Columbia it is 35 tons per square mile per month. The Alberta regulations provide for "due allowance" for normal background levels. In order to evaluate the importance of this difference it would be necessary to know a great deal about the dustfall from natural sources, the density of industrial dust sources, and competing alternative uses. Multiply the complexity of

this task by the number of small differences that appear in the tabulated standards and you have some appreciation of the difficulties that would be involved. To provide a meaningful comparison it would be necessary to assemble a team with all of the scientific and technical expertise of the government agencies that promulgated the standards in the first place.

Perhaps the basic similarity that has been found between the environmental standards published by the study jurisdictions is one of the more significant findings of this study. It indicates that government personnel are very aware of the developments in other jurisdictions and do make an effort to examine their own positions in comparison with those of their colleagues. This finding was borne out, in large measure, by our interviews.

Finally the concluding chapter addresses difficult problems of enforcement. Hard data on enforcement of environmental standards are still largely lacking. However on the basis of a review of legislation, policy documents and permits as well as several case examples, and interviews with enforcement officers, we have examined enforcement strategies and techniques and offer certain suggestions.

CHAPTER 2

A MODEL PROCEDURE FOR SETTING ENVIRONMENTAL STANDARDS

Before one can begin to compare environmental standards set by different jurisdictions, one must have a clear idea of the purposes for which such standards are set and a framework for comparison. The object of this chapter is to set forth an "idealized" model for the promulgation of environmental standards. It should not be thought that the model represents what actually takes place, nor that we are unaware of political realities that inevitably cause real decision-making systems to depart from the ideal. While our model presents the process as one rationally based on scientific information and information about the goals and values of the population, the real world is far different. In fact, the standard-setting process we have outlined is probably not followed with any rigor anywhere in Canada. Rather, this model is intended as a basis for comparing the approaches taken by the various jurisdictions that we are studying.

WHAT ARE STANDARDS?

One of the first barriers that must be overcome is terminological. Writers in different fields clearly mean different things when they write about standards, guidelines, and objectives. Some legal writers distinguish between guidelines and standards, for example, on the basis of their legal impact. For them, a standard is a legally enforceable specification of the amount of pollutant that may be discharged or present in the ambient medium. There is a tendency for the popular press to follow this distinction. In contrast, technical writers would not necessarily follow this distinction. For them, an objective might refer to the particular uses that are desired for the water or air. A standard would specify the amount of contaminant that could be discharged, but it might or might not be legally enforceable. The model we will outline in this report is intended to establish a consistent terminology for the purposes of this report. When we come to evaluate the particular practices and standards of each jurisdiction we shall relate our findings to the terminology we have used in this model.

DEFINITION OF TERMS

"Objective" denotes a goal or purpose toward which an environmental control effort is directed. Examples of objectives are as follows: to preserve and enhance the salmon fishery in these waters; to prevent crop damage caused by air pollution; to protect the public health.

"Criteria" are compilations or digests of scientific data that are used to decide whether or not a certain quality of air or water is suitable for the chosen objectives. A simple example of a criterion that might be used to judge the suitability of water quality for a certain species of fish might be:

<u>Concentration of pollutant</u>	<u>Effect</u>
A mg/L	No adverse effects noted
A mg/L	Lowest level at which sublethal effects noted
B mg/L	Lowest level at which mortalities noted
C mg/L	No survival

"Standard" denotes a prescribed numerical value or set of values to which concentrations or amounts actually occurring in the ambient medium or the discharge to that medium may be compared, whether legally enforceable or not. Examples of standards are:

Average concentration of Pollutant X in the air shall not exceed Y micrograms per cubic meter during any 24-hour period. (Ambient)

Maximum daily discharge of Pollutant A from Point Source B shall not exceed Z kg. (Effluent)

HOW SHOULD STANDARDS BE SET?

The traditional, technically-based approach to setting standards is as follows:

1. Identification of uses of the ambient resource to be protected or objectives to be met.
2. Formulation of criteria through collection and/or generation of scientific information.
3. Formulation of ambient quality standards from the criteria.
4. Development of effluent standards for discharges into the environment that will produce a quality meeting the ambient standard.
5. Development of monitoring and other information-gathering programs that will refine the data inputs to the previous steps and provide feedback on whether the objectives are being met.

Each of these components in the standards-setting process will be examined in the following sections.

IDENTIFICATION OF OBJECTIVES

The setting of objectives for pollution control and environmental preservation/restoration is the keystone of any rational standards-setting process.

Scope and Character of Objectives

Traditionally, selection of objectives has taken the form of identifying uses to be protected, implying human purpose. Surely this is an excellent starting point, and one still widely used in practice, but during the 1970's, with increased scientific and public awareness of ecological principles, it came to be recognized that appropriate objectives might include more than just the very readily identifiable human uses such as water supply, water-based recreation, and fishing in the case of water, and respiration and damage-free agriculture in the case of air. A bold expression of the turning away from a purely anthropocentric approach to water quality objectives was the U.S. Federal Water Pollution Control Act of 1972 (PL 92-500). In the words of Philip T. Cummings, who was Senate majority counsel for this bill, "One of the organizing principles of the 1972 act... was that the policy of the government is to restore the integrity of the water. That is not dependent on some judgment about its use but about its original character. That is an ecological principle rather than the economic principle of beneficial use."(1)

In practical terms, however, the objectives of the legislation were expressed in a way closely related to human uses. Section 101(a)(2) stated that "it is the national goal that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife, and provides for recreation in and on the water be achieved by July 1, 1983." This is the so-called "fishable/swimmable" goal.

Spatial Scale for Objectives

The question of the size of areas for which objectives should be set must be examined from the standpoint of Canadian geography and legal institutions. Clearly, in a country as immense as Canada, with marked regional contrasts in landforms, climate, economic activity, population density, and other variables, national objectives would not always be a reasonable way to proceed. However, there are both technical and constitutional reasons why a nationwide approach is appropriate for certain special cases. The most obvious example of a broad-brush, federal-level objective is protection of the fisheries, an objective that is clearly within the federal government's power to establish and pursue. Another example is alleviation of the acid rain problem. A good case can be made for federal involvement here because of the mobility of air masses. The Peace, Order, and Good Government power of the federal government places it in a position to prevent the casting off of harm from one province to another, and the international repercussions of acid rain also point to the need for federal involvement.

While the legal picture is even more favourable toward objective-setting on a provincial scale, most of the provinces are themselves so large and so diverse that a blanket approach is not always appropriate. It would be irrational, for example, for provincial authorities to set as an objective that all waters of the province be "swimmable"--in the sense that implies high microbiological quality--when in fact many waters may never be "swimmable" in a physical sense, having rapids, dangerous currents, etc. The next step, then, would be an approach focusing on specific bodies of water, that is, specific lakes, rivers and streams, or identifiable reaches of the latter. The difficulties of identifying objectives for every one of the bodies of water in a province are large indeed, but objective-setting overall is, or should be, an ongoing process rather than something done once and for all. Thus, early attention can be given to sites where problems are perceived, for in fact these are usually areas where conflicts over objectives exist, such as industrial development vs. fishery preservation. Detailed consideration of nonproblem areas can be deferred, and perhaps an interim objective such as "preservation in its present state" may be formulated.

Objective-Setting Process

Decisions about objectives for air and water resource quality are fundamentally neither technical nor legal decisions. In a democratic society the objectives should express, as accurately as possible, the collective will and perceptions of all people likely to have some interest in the condition of the resource. While ultimately these expressions must be gathered, evaluated, and summarized by the regulatory authority, the opportunity for public input must be systematically provided for. This suggests that the formulation-of-objectives stage is one of the most important points in the standards-setting process for contact between the regulatory agency and the public. This contact can take any of several forms: public information publications, advertisements soliciting written submissions, public presentations, meetings, workshops, and hearings. A recent publication by Ellis and Disinger(2) gives the results of 105 case studies of project planning in wastewater management, water development, and highways and road construction. The association of variables relating to process and context of public participation with variables related to outcomes of project planning was studied. Table I shows the results of the correlations. As the authors note, the most favourable outcomes of the planning process (dependent variables) tend to be associated with procedures (independent variables) characterized by effective information exchange, that is, two-way flow of information. Favourable results are obtained when agencies actively seek knowledge of the public's needs and attitudes, especially if the public has been well prepared to express its opinions by prior dissemination of information by the agency. Two-way communication events, such as workshops and open meetings, may be especially effective. Counterproductive factors include redefinition of public demand by the agency--the attitude that "We know best what you really need"--and attempts by the agency to "sell" an already-made decision.

Table 1. Correlations of variables documented from 105 case studies of project planning with public participation.

Dependent variable	r	Independent variable
Public opposition develops	0.36 - 0.34	Agency intends to "sell" premade decision Low temporal relevance ¹
Information critical to project planning becomes available to agency	- 0.31 - 0.31 - 0.34 0.35 0.43 - 0.44 0.50	Redistributive policy Small project: high social significance Agency intends to "sell" premade decision Agency seeks project alternatives Agency seeks information on public needs Redefinition of public demands Agency seeks public attitude data ²
Public contributed alternatives information probably available only from public input	0.38 0.33 0.32 0.32	Agency seeks attitude data ² Meetings Agency seeks public needs data Pamphlets
Public needs and goals identification	0.55 0.49 0.44 0.34 0.34 0.33	Agency seeks public needs data ² Agency seeks public attitude data ² Agency seeks project alternatives Meetings News releases Agency endeavors to inform public
Inform and educate public	0.49 0.39 0.39 0.36 - 0.33 0.32 0.32	Agency seeks public needs data ² Meetings Pamphlets Agency seeks public attitude data ² Hearings Workshops News releases
Broad socioeconomic participation	0.32 0.32 0.31	Meetings News releases Agency seeks public needs data ²
Enhancement of planning dialogue	0.39 0.37 0.36 0.35 0.33 - 0.31	Agency seeks needs data Agency seeks public attitude data ² Workshops Meetings Agency endeavors to inform public Hearings
Participants perceive participatory program to be too limited	0.56 0.44 0.39 - 0.31	Redefinition of public demands Agency seeks to "sell" premade decision No education of participants Low temporal relevance ¹
Inadequate education effort - public unprepared to participate	0.32 0.32	Small project: high social significance No education of participants
High degree of compromise	0.41 0.35 - 0.34 0.33	Agency endeavors to inform public Agency seeks public attitude data ² Redefinition of public demand Newsletters
No resolution	0.46 0.39 - 0.36 0.34 0.34 - 0.31	Agency seeks to "sell" premade decision Redefinition of public demand Temporal relevance low ¹ Redistributive policy Small project: high social significance Agency seeks public attitude data ²

The value "r" is a measure of the strength of the relationship between variables. It ranges from -1, indicating a perfect inverse relationship, to +1 indicating a perfect positive relationship. Reproduced with permission from *Journal Water Pollution Control Federation* 53, 1564 (1981). (2)

*N = 105

¹ Project will set no precedents for subsequent projects (i.e., it is highly routine).

² Relative to the planned project.

Kolankiewicz's (3) account of the series of hearings held in British Columbia on water pollution control "objectives"* illustrates some of these points. The content of these hearings was explicitly limited to technical considerations. This effectively discouraged input from the public at large. There are many members of the public who may not have access to facts and figures but can make a contribution to objective formulation by raising matters such as general economic conditions, aesthetic values, and spiritual values (the latter may be especially important to native peoples). The forum provided for these expressions of opinion should be as open, accessible, and inviting as possible. Lack of accessibility also was mentioned as a problem. The first series of hearings in B.C. was held in Vancouver, Victoria, and Kamloops, although for the last few hearings less formal meetings were held elsewhere. It is a great deal to expect of the ordinary citizen that he travel and lodge away from home, perhaps at great expense, if he is to have a hope of making his aspirations heard. It is therefore far preferable that agency-public encounters come to the people, not the people to the encounters. A third problem illustrated by this series of hearings was the extreme formality of the hearing format, which also discouraged effective public input. As Ellis and Disinger (2) have said of this type of contact, "Dialogue is procedural, suppressed, and stilted, if present at all." Presumably, though, industrial representatives at hearings, who have a great deal more access to technical expertise, company money to cover travel expenses, and ample familiarity with formal presentation situations, find hearings a reasonably satisfactory format for input into agency decisions.

The result of objective formulation with due regard to local conditions has often been expressed in stream classification systems. Fish and Wood (4) of the Thames Water Authority, for example, set forth a river classification scheme ranging from the highest class, the current and potential uses of which include potable water supply abstraction with minimal treatment, game and high-class coarse fisheries, and high amenity value, to the lowest, waters that are grossly polluted and likely to cause nuisance, rather than have any safe uses. Many such schemes are based on the assumption that there is a strict hierarchy of uses, e.g., if water is safe for

*Objectives in the sense of a quasi-standard, not as defined in this paper.

human consumption, it is safe for aquatic life. This is often erroneous and therefore this approach can be simplistic and should be used only with caution.

QUALITY CRITERIA

Criteria consist of the supporting scientific data that enable us to answer questions such as, "Is this water safe to drink?" "Is the air safe to breathe?" "Can this lake support a healthy trout fishery?" Because of the extremely large number of elements and compounds now contained in our air and water resources and the many ways they affect potential uses of the resources, the answers to these questions can be very complex.

Information Needs

In contrast to the formulation of objectives, the formulation of criteria is strictly a scientific matter. It involves gathering of data on the effects of potential pollutants and combinations of pollutants on the uses in question, and in the absence of data, experimentation to generate such information. This is never a small task, and in the case of the more sensitive objectives, can be formidable indeed, for several reasons. First, the number of substances and other quality parameters that can affect sensitive objectives is very large. According to Loucks (5) in the USSR over 400 harmful substances have been defined for drinking water, and over 60 for fish life. Janardan and Schaeffer (6) state that an estimated 60,000 organic compounds are produced and used by various industries in the U.S. The number of substances is growing rapidly; many new chemicals are synthesized and thus added to our environment each year. Second, the effect of any substance in the air or water is rarely, if ever, expressible in black-and-white terms. That is, if a certain concentration of a substance clearly causes no harm at all, it is unlikely that a marginally higher concentration will clearly cause substantial harm. Rather, the effects of substances are usually more accurately represented by a continuum from states of nearly perfect safety (or perhaps even necessity in the case of certain trace elements), through states that may cause distress to certain sensitive individuals or species, to those causing more widespread and more severe harmful effects at increasing levels. Some pollutants appear to have a "threshold effect". Third, this approach does not take into account the possibility of synergistic and antagonistic effects among pollutants, that is, the possibility that one or several pollutants may either intensify or counteract the effects of one or several others.

Form of Criteria

An idealized criterion for a particular use would therefore identify a very large number of pollutants and combinations of pollutants, assess the risk of adverse effects occurring at a number of potential levels of those pollutants, and identify and evaluate the risk of effects of pollutant interactions. In practice, such criteria would be enormously difficult to generate, and the expense of doing so could not be justified. On a practical level, therefore, we are limited to formulating criteria on the basis of a limited number of parameters of the greatest and/or most obvious concern, gathering the available information on conditions likely to be clearly harmful, clearly safe, and to lie in the "grey area" between, and considering any interactions that may come to light.

AMBIENT QUALITY STANDARDS

The third step is the formulation of ambient quality standards, that is, the prescription of the quality of water or air that is deemed necessary to protect the desired objectives, in the light of scientific knowledge supplied by the criteria and of socioeconomic factors affecting the control of pollution. Ambient standards may set upper limits on the mass or concentration of harmful substances, may set lower limits on the presence of desired substances such as dissolved oxygen, or may prescribe a range of desirable values (e.g., for pH). The values may be specified as averages over some given time period, extreme values never to be exceeded, or values that may be exceeded only for specified time periods.

The setting of ambient standards is not fundamentally a technical decision. Even if one assumes that the criteria provide a very complete technical background for decision, the standards set inevitably reflect value judgments. This is an important point, and one that has often been misunderstood. Official misunderstanding is the root of many of the complaints about the administration by the U.S. Environmental Protection Agency of the provisions of PL 92-500. Noss and Marks (7) state that "Most current standards are almost identical to the criteria... EPA has taken a dim view of proposed standards that vary from the water quality criteria published in its 'Red Book'." A position paper of the Water Pollution Control Federation (8) further states that "Where... criteria are simply adopted in toto without consideration of water use and value, standards are usually unrealistic. Thus, criteria must be

conditioned by the realities of each waterway if they are to be translated into useful standards."

Technical Evaluation

Noss and Marks (7) have provided a conceptual model of the process of setting water quality standards (Figure 1). Of the four external inputs to the "technical" evaluation of alternative water quality standards, the first three already have been discussed.

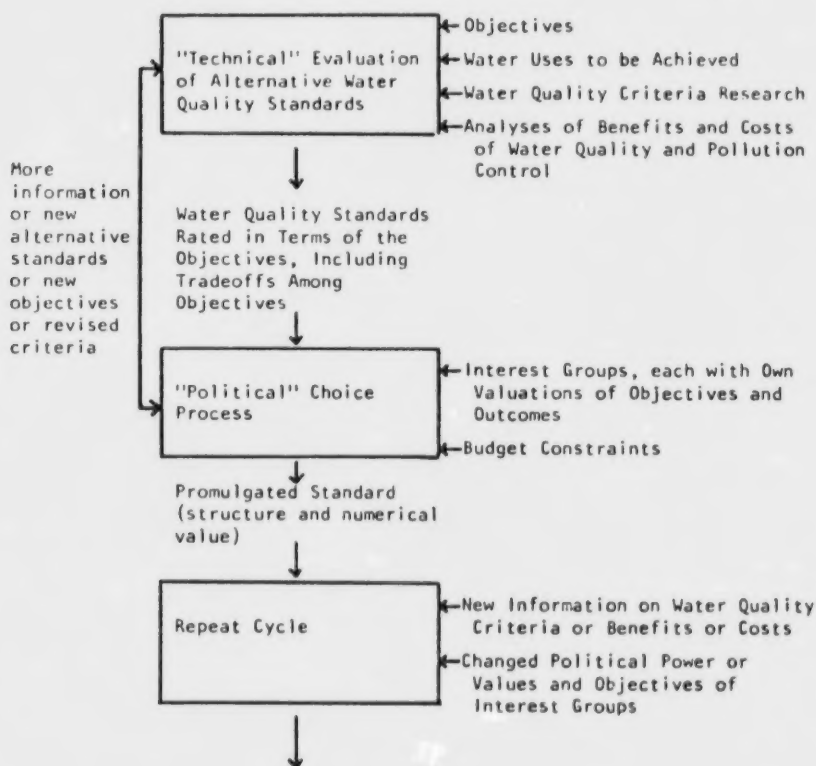


Figure 1 -- Conceptual model of the process by which water quality standards are set. Reproduced with permission from Journal Water Pollution Control Federation, 53, 426 (1981).(7)

The fourth, analyses of benefits and costs of quality and pollution control, is both vital and difficult. At this stage it is possible to take into account only the tangible, quantifiable benefits and costs. For

improvements in ambient air quality, the benefits may include lower health care costs, fewer days lost because of respiratory problems of the work force, reduction of damage to crops and ornamental plantings, decreased maintenance cost of buildings and public areas, and increases in revenues from tourism. For improvements in water quality, benefits might be expected in the form of lower water treatment costs for domestic uses, improved harvests of fish, increased sales of boating and other water-based-recreation equipment, and again, increased revenues from tourism. The costs are those associated with all the technical and administrative measures necessary to produce the ambient standard being considered. This implies at least a preliminary exploration of alternative means of producing the desired ambient quality and cost estimates for these alternatives. Failure to consider and weigh the benefits and costs can lead to nonoptimal or even ludicrous decisions. For example, Krenkel (9) cites the case of the Kewaunee Plant on Lake Michigan, which is equipped with cooling towers to protect an estimated 1.4 to 10.4 kg of fish (mostly alewives) per day that would be at risk if once-through cooling were used. The total cost of this protection, including the facilities, materials, labor, etc., brings the cost of protection to between \$1,729 and \$5,572/kg of fish!

This phase of the standard setting will require specialized input not only from scientists but also from economists and experts in various industries. All this is not to say that the evaluation of benefits and costs should be limited to this input from the "experts" -- it is well recognized that intangible and nonquantifiable benefits and costs will result from a water quality decision. These are recognized at a later stage of the process.

The output of this technical evaluation stage will be a number of alternative water quality standards, with an evaluation of each in terms of how well it meets the proposed objectives, what risks it poses to the achievement of the objectives, and the benefits and costs that are likely to flow from the achievement of that standard. Each alternative standard will include recommended limits on the parameters relevant to the uses being protected. When these alternatives are being formulated, attention must be paid to two other practical problems, as noted by Krenkel (9). First, does the standard, determined largely from laboratory study and the literature, make sense in the real world? For example, is it possible to conceive of a situation in which a body of water would be in regular violation of

standards developed, on the basis of good technical data, to protect fish life, and yet be found to support a healthy fish population of the desired type? Second, is the proposed standard measurable by methods currently available for practical field use? A nonmeasurable standard not only cannot be enforced, but actually invites violation and disrespect for the entire regulatory process. Means for controlling substances likely to be harmful in less-than-detectable concentrations are discussed under "Feasibility of effluent standard compliance", below.

As Noss and Marks (7) point out, the primary purpose of water quality standards is to maximize the level of protection of beneficial uses, and the second purpose is to minimize the cost of meeting the standards, and the job of the standards-setting body is to balance these conflicting objectives in a way that yields the greatest net social benefits. At this point in the process, the standards-setting agency has in hand (or should) the best information that the physical, biological, and social sciences can provide.

Political Choice Process

Information needs. If the regulatory agency has already done an effective job of securing public input into the setting of objectives, some information about public preferences may already be at hand. However, it may be appropriate to give members of the public and interest groups a further opportunity to consider and comment explicitly on proposed standards, to react to information generated in the technical evaluation, to bring forward new data that may not have been accessible to those performing the technical evaluation, to state preferences concerning hard- or impossible-to-quantify matters such as aesthetic and spiritual values, and to give views on the acceptability of the risks inherent in the various proposed standards and willingness to pay for necessary measures. Also, in situations where ambient quality is largely governed by the quality of effluent from one or very few sources, the setting of ambient quality standards becomes, in effect, also the setting of effluent quality standards, and the equity and bargaining considerations outlined more fully below may be aired at this stage.

Risk acceptability. The acceptability of a risk may depend not only on the character of the use that is at risk, but also on the attributes of the risk itself. Jacobson (10) has constructed a table illustrating this point (Table II). These considerations, applied by

Jacobson to the case of risks associated with acid rain, could be applied equally to other pollution situations. Consider, for example, the case of a body of water supporting a fishery that is threatened by a waterborne discharge. Consideration of the economic importance of the fishery to the community will indicate a pressure toward a higher standard if the fishery is vital to the sustenance of a native community or if income from tourists who visit the area for fishing is an economic factor in the community, than if it is used only for recreational purposes by local people. Given, however, that one of these situations is the case, for example, that the fishery is vital to, and used only by, a native community, Jacobson's analysis predicts that more protection against risk will be demanded if, for example, the type of damage predicted is rare, that is, alien to experience and therefore fear-inducing, rather than common, or if the pollution would come from an industrial plant owned by outsiders (innocent party at risk) rather than from the community's own waste collection system (polluter at risk).

Table II. Public acceptance of environmental risks. Reproduced with permission from the Journal of the Air Pollution Control Association, 31, 1071 (1981).(10)

Less acceptable	More acceptable
Catastrophic	Subtle
Imminent	Deferred
Permanent	Temporary
Irreversible	Recoverable
Probable	Unlikely
Rare	Common
Obvious	Intangible
Unpredictable	Predictable
Abstruse	Understood
Quantifiable	Nonquantifiable
Global	Localized
Involuntary	Voluntary
Consequence of human action	Consequence of natural processes
Innocent party at risk	Polluter at risk

Benefit - cost judgements. Here too is a point at which the public can comment on whether the protection of certain uses or the maintenance of a certain quality is

"worth it." Several situations recently outlined in the Vancouver press may be combined to illustrate the choices that are available. In the first instance (11) it was reported that air pollution caused by the coincidence of an inversion layer in the atmosphere with a weekend during which outdoor burning of leaves and other garden debris was permitted resulted in problems for area residents with asthma or air passages that are easily irritated. Another story (12) told of two women whose allergies to environmental pollutants were so severe that they routinely use gas masks when near the fumes given off by cars. Consider, then, two proposed sets of air quality standards, the first intended to make the air safe and comfortable to breathe, even for those suffering from asthma, emphysema, etc., at nearly all times, to be implemented by alternatives to outdoor burning such as extra municipal pickups for garden debris, the second intended to make the air safe even for those with extreme environmental allergies, to be implemented by such measures as ending outdoor burning plus retrofitting of pollution-control devices on older autos and increased controls on stationary industrial sources. The first standard probably would be perceived as desirable, because the benefits would be fairly widespread, including many of the elderly, and the costs fairly modest. The second standard probably would be rejected as benefiting too few and imposing large costs on the vast majority. Somewhere in between lies the level that a broad cross section of the public might feel is a correct balance.

EFFLUENT STANDARDS

The object of the next stage of the standards-setting process is to move from a statement of the desired condition of the air or water to standards defining limits on discharges to the resource that will permit the desired state to be attained. Ambient standards and effluent standards sometimes have been regarded as alternative approaches to regulation, but this view is incorrect. The approaches are supplementary and each is necessary; an ambient standard alone is unenforceable because it gives no indication of cause and effect nor any guidance to either regulatory body or the regulated about the necessary courses of action, and an effluent standard lacking a basis in an ambient quality goal has no reasonable foundation in reality -- it is the equivalent of the parental "Because I said so!"

Like the setting of ambient standards, the setting of effluent standards requires both technical and nontechnical input.

Technical Considerations

Mathematical models. The science and art of constructing mathematical models to relate ambient quality to inputs of pollutants and to pollutant removal mechanisms inherent in the resource has made large advances over the last several decades. Before the widespread use of computers for such simulations, the possibilities for modeling were very limited and were restricted to cases involving only a few pollutants, sources of pollution inputs, and simple removal mechanisms. Present-day knowledge enables regulatory agencies to take account of more types of pollutants, a greater number of sources within an airshed or watershed, and more sophisticated behaviours of pollutants once they have entered the resource. The literature on the construction and use of mathematical models for investigations of air and water quality control is voluminous, and no attempt will be made here to review it. The regulatory agency will choose among the available approaches according to the complexity of the situation, the ease of gathering input data necessary for application of the model to the situation, and the ability of the model to produce results that approximate closely conditions in the "real world".

Many of the mathematical models used for pollution control have been intended to minimize an objective function, usually the cost of control measures, subject to a set of constraints, the most important of which is the desired quality of the pollution-receiving resource. Other constraints may include minimum treatment requirements, uniformity of treatment requirements, and prohibition of certain methods of treatment.

Models also can be constructed to include the effects and costs of control measures other than direct control of point sources of pollutants. Examples of such measures are augmentation of stream flow to dilute pollutants by controlled releases of water from upstream impoundments, in-stream aerators to augment natural replenishment of a stream's dissolved oxygen, and harvesting of aquatic vegetation to remove nutrients from the system. The effects of, and effects of control measures on, nonpoint sources of pollution, such as runoff from agricultural lands, also can be included.

The great utility of mathematical models lies not in that they give one "correct" answer, but that they permit, with very modest expenditures of extra time and money, sensitivity analyses that can yield much information about the response of the cost function to changes in the

input data, the assumptions about pollutant behaviour and fate, or the constraints, and can therefore generate a number of options for further consideration.

The end product of the modeling process, therefore, will be, for an already-determined ambient quality standard, one or more sets of constraints with the attendant values generated by the model for the quality of each point source of pollutants and the costs entailed.

Form of the effluent standard. Popel (13) has pointed out that fixed standards, i.e., standards expressed by one fixed value that is never to be exceeded, are not appropriate measures for water pollution control, because a fixed standard will always be exceeded, with the probability of exceedence decreasing with increased laxity of the standard. His analysis can be applied to air pollution as well. The input parameters for treatment facilities are highly variable because of variations in the processes generating the wastes, and these input variations may cause differences in response of the treatment process, amplifying the variations. Popel suggests that the appropriate measure is a combined standard consisting of a standard value and a permissible probability of exceedence, and that stratified random sampling of effluent data be used for control. The combined standard also has the advantage of using all the data collected in judging conformity of effluent quality to standard, not merely the highest single value in a time period, and thus provides a more truly representative idea of compliance. This does not, of course, suggest that extreme values be disregarded altogether, because these values can be quite critical in their effects.

Popel also points out that the variability of the discharged loads and the variability of the receiving water flow (or atmospheric conditions) simultaneously determine the variability of the pollution of the resource. This could be taken into account in the mathematical modeling phase.

Coordination of control efforts in various media. Another technical consideration, and one that is often overlooked and sometimes very difficult to perform because of the lack of administrative mechanisms for doing so, is the coordination of pollution control efforts to protect air, water, and land. Pollutants removed from a waste source must still be disposed of somewhere, somehow. Some methods of pollutant removal and disposal may amount to little more than intermedia transfers of problems. Consider, for example, an aqueous

effluent treatment system that produces an effluent meeting standards for discharge to a receiving water as well as a sludge containing high concentrations of toxic chemicals. The sludge may be incinerated, with release of toxics to the air, or disposed of on land in such a way that the toxics may be leached out and return to an aqueous environment. An effective means of accounting for such side-effects may be to rule out certain types of disposal options, such as sludge incineration, in constructing the mathematical models, when it appears that they may lead to substantial side effects.

A report on a regional environmental quality management model by Russell and Spofford (14) of Resources for the Future, applied to a heavily industrialized area, indicates that by ignoring linkages between air and water standards regulatory authorities can be making policy decisions based on incorrect cost information, that treatment facilities can thus be underdesigned, and that while for the case studied the costs involved in ignoring interactions are not very large as a fraction of the cost of meeting the most stringent water quality standards for the region, some costs are considerable on both absolute and per-capita bases and fall directly on individuals. The authors report that the cost of including such linkages in the model was modest, and the gathering of data on the linkages was not especially difficult.

Feasibility of effluent standard compliance. Like ambient standards, effluents standards generally should be set at levels that make the monitoring of compliance possible. However, in the case where serious reservations exist about the safety of extremely low or even non-detectable amounts of a substance, a very low or even "no-discharge" standard may be set and the cooperation of industry in the form of process change and of other government entities in restricting sale or use of the substance may be sought. Garber (15), in a paper deeply critical of the effects of U.S. PL 92-500 on waste discharge practices of the City of Los Angeles, cites the following case: The imposed limit on mercury in discharges to the ocean off California implies an average contribution of only 0.4 mg mercury per person per day in the population of three million served by the main municipal treatment plant. It is Garber's opinion that the personal use of medicinals such as merthiolate and mercurochrome would be significant in this context, and that achievement of this effluent standard would require a legislative ban on these and other commonly used products containing mercury. A ban so widely affecting commerce would, of course, be well beyond the powers of local authorities in Canada as well as the U.S. When

faced with a dilemma such as this, the regulatory authority may consider re-thinking its proposed standards, making sure that they have a firm basis in scientific data, and, if a very stringent standard still seems called for after re-examination, may wish to set a more lenient interim standard and reserve pressure for conformity with the more stringent standard until conformity is in fact possible. An alternative means for controlling substances that may be present in industrial discharges in less-than-detectable concentrations is that of requiring the industry to submit periodic materials balances for the questionable substances. Quantities of the substances accounted for in waste products, plus any unaccounted-for differences between amounts acquired and amounts in output, would be presumed to have been discharged to the environment.

Nontechnical Considerations

Equity. The fundamental fairness of pollution control regulation is an important issue at this stage of the standards-setting process. As Lyon (16) stated in 1965, "In any democratic country regulatory activity is attuned to the concept of equity. This concept is found in many other regulatory endeavors and is one that is always the approach most likely to gain general public acceptance. It is also a concept which very often is difficult to explain or justify in scientific terms." More recently, Jorling commented in a 1981 discussion (1) of the origins of the U.S. PL 92-500 that minimum national uniformity was "something that industry has sought and that industry deserves, that there should not be a competitive advantage that flows to an industrial activity as a function of where it is located as a result of an environmental control requirement..." Other participants in the same discussion stressed that a great deal of the motivation for a uniform permit approach stemmed from the effort to prevent one part of the country from luring industrial plants with the promise of less stringent requirements. Thompson (17) quotes authors of several case studies on environmental regulation as recommending that the Canadian federal role in water and air quality management be limited to establishing minimum national effluent guidelines and standards to keep "pollution havens" from developing. Provincial regulatory authorities, who are in a better position to take specific local conditions into account, nevertheless must keep this concern in mind. However, Okun (18) has pointed out that in a given industry all the other costs of production probably are not uniform among plants, and that an enforced uniformity of pollution control costs may distort investment decisions.

One must distinguish between regulation of existing discharges and regulation of planned discharges. In the former case, the pressures toward equity, in the form of uniformity, would be considerable because the fundamental decision on location already has been made, whereas in the latter case, economic incentive to locate where the effects of waste disposal are less harmful and/or waste treatment is less costly can and should be offered.

This problem is not confined to industrial regulation. Local politicians may be concerned if the citizens of their municipalities have to pay more for pollution control facilities than the citizens of municipalities more favourably located. The financial consequences of a uniform standard approach to municipal waste treatment were outlined by Buxton (19) of Environment Canada. He estimated that, as of 1978, about 90% of the Canadian urban population was served by a minimum of primary wastewater treatment (basically, settling to remove suspended solids). About 98% of municipal discharges to the Great Lakes basin were given the equivalent of secondary treatment (settling plus biological treatment to reduce oxygen demand). If all urban centers across the country were required to provide secondary treatment, the estimated cost would be about \$1.5 billion, excluding costs for land, legal fees, replacement, interest, and collection system expansion. Buxton suggested that the preferable approach is setting requirements on a community-by-community basis, with the primary responsibility resting with the provinces.

Brill et al. (20), while acknowledging the desirability of equitable control measures, call further attention to this major drawback--that "a major trade-off between equity and cost usually occurs." That is, the more uniform the requirements, the more the achievement of the desired degree of pollution control costs society as a whole, mainly because all are required to meet standards that, on a scientific basis, need only be met by one or several of the most critical dischargers. Because of its revelations about the magnitude of costs incurred by uniform standards, this paper merits further discussion. The study was performed by using data for the Delaware Estuary, a highly industrialized area, in which 44 points of discharge of oxygen-demanding wastes were represented. The underlying assumptions are that, for existing dischargers, equity is "fairness" as perceived by the dischargers, that all are equals and will be treated equally unless they agree among themselves that they are unequal, and that waste reduction efficiency (percentage removal of oxygen demand) is an acceptable measure of a

discharger's share of the waste reduction task. As a baseline case, a simulation was run in which the objective was to minimize the sum of the waste removal costs for the group of dischargers, with no restriction on the efficiencies required of individual dischargers. For a desired ambient minimum of 3 mg DO/L, discharger efficiencies ranged from 0.2 to 0.9. The authors state that this wide range is typical of least-cost solutions. On the other hand, an essentially uniform-treatment program required an efficiency of 0.78 on the part of all dischargers, at a cost almost three times that of the least-cost program. The authors propose several other schemes that can be viewed as equitable, e.g., a zoned uniform treatment approach, a limitation on total program cost and minimization of the sum of deviations from average efficiency, a range equity measure minimizing the range of removal efficiencies subject to a cost constraint, and minimization of the maximum removal efficiency. The latter three cases particularly indicate that very major savings are possible with minor deviations from strict equity, up to a point. In all these cases, only one or a very few dischargers are critical and are required to treat at higher levels. Although the numerical results of this study apply only to its specific conditions, they do suggest that in certain circumstances the imposition of uniform treatment requirements can be very costly to society as a whole and, in fact, wasteful. One suggested alternative is uniform treatment at some lower level and subsidies for critical dischargers forced to treat at higher levels.

Bargaining. A final nontechnical consideration in the process of setting effluent standards is the bargaining process between the regulators and the regulated. While this is only one consideration at the final stage of the rational model of idealized standards-setting discussed in this section, it is, according to Thompson (17), actually the essence of the regulatory process in Canada. He states that "no matter how normative measures are expressed in a statute -- whether as policy guidelines or as command prohibitions -- the end result in the case of environmental regulation is a bargaining process." The actual operation of the bargaining process in Canadian regulation will be examined in a later part of this report. This part will examine only the place of bargaining in the idealized, scientifically-based standards-setting process described here. We suggest that bargaining, involving the regulators, the regulated, and other interested parties, can perform several useful functions in this context: first, refining whatever approaches are dictated by considerations of equity to allow for real differences among dischargers; second,

acting as an interface between the technology and economy of pollution control and the economics of the nation and the world; third, revealing the gaps in knowledge and information available for regulatory decisions.

As indicated in the section on equity, pressures for uniformity in effluent standards will be considerable. However, if there is any reason why a discharger may consider itself sufficiently different from its competitors to warrant more lenient standards, this is the point at which such reasons will be advanced. Often these may be quite legitimate, but may involve the revelation of proprietary technical information or information about the discharger's financial position that it may have been very reluctant to reveal in a less private setting. Honest dealings at this point, especially if the regulatory authority also takes into account input from other interested parties, can be very helpful in "fine tuning" the proposed effluent standards.

The bargaining process also can act as an interface between the technology and economics of pollution control, which until this stage have been considered in isolation, and the economics of the country and the world. Because of the perceived need for confidentiality about financial matters, this may be the first opportunity given to the regulatory authority to consider the effects of proposed effluent standards and prospective expenditures on a particular discharger's competitive position within the Canadian economy, and, if standards for an entire industry are being set, to consider collectively that industry's position in the world market.

Finally, the bargaining process can vividly draw attention to the weak points of the scientific and economic information supporting the standards-setting process. Often, bargaining will take place precisely because such weak points exist and leave room for maneuvering. As Thompson (17) has stated, "The reasons why bargaining and negotiating characterize the process of environmental regulation, even in cases where the command/penalty mode of legislation suggests a more formal, adversary style, are believed to lie in the knowledge gaps and uncertainties that pervade environmental issues." But this situation can be turned to advantage if the regulatory authority takes note of the subject areas of the bargaining process and incorporates these areas into its plans for further data acquisition during subsequent reviewing and revising of standards.

MONITORING AND INFORMATION ACQUISITION

Standards arrived at by the processes described above should not be regarded as being fixed for all time. Science advances, economic conditions change, and societal values shift. The relevant question is, "Are the standards doing the job they were intended to do?" In other words, are they contributing to fulfillment of the objectives originally chosen? Yet even those objectives may not remain fixed; they also may need to be reviewed from time to time. It is important that the regulatory authority be aware of changing conditions and new information that may have a bearing on the effectiveness of standards.

The information most obviously necessary is monitoring data on both effluents and ambient conditions. Permits often will require a specific monitoring program to be carried out by the discharger, with periodic reports to be sent to the regulatory authority, or the regulatory authority itself may carry out a monitoring program. This serves several functions: first, it promotes "waste awareness" on the part of the discharger and a regularly renewed opportunity to cooperate with the regulatory authority to solve any problems that may appear; second, it provides a check on the feasibility of meeting the effluent standards; third, it yields data that, in combination with monitoring data on ambient conditions, can be used to verify the predictions of mathematical models about the relationship of discharges to ambient quality.

In addition to being used in the last-mentioned way, data on ambient quality can be coupled with studies and observations of actual conditions to provide revisions and refinements to criteria. Hence, the whole chain of information, from what ambient quality will fulfill the objectives to what effluent quality will produce the desired ambient quality, is strengthened.

The need to keep up with other scientific and economic developments relevant to standards-setting underlines the need for adequate numbers of knowledgeable staff at the regulatory agency. Apparently, this is one of the most serious shortcomings of regulatory activity in Canada. As Thompson (17) has stated, "As to the present situation in Canada, governments must be condemned for failing to ensure that their environmental regulators are adequately informed and that there are enough of them."

BEYOND THE EFFLUENT QUALITY STANDARD--TECHNOLOGY-BASED EFFLUENT STANDARDS

This section will deal briefly with the concept of technology-based effluent standards. The U.S. has based its federal water pollution control efforts for the past decade on this concept, and, because it appears that substantial departures from this approach will occur in the near future (21), an evaluation may be instructive.

Technology-based effluent and emission standards are defined by Freeman (22) as "quantitative limits placed on all dischargers, where quantities are determined by reference to the available technology defined in terms of what is 'practical', 'possible', or 'achievable'." These limits are designated without reference to any ambient standards, balance of benefits and costs, or other guiding principles.

The reasons for the adoption of the technology-based approach are many and complex. One group of reasons centres around the practical difficulties of using a water-quality-based model of the regulatory process. Here are a few brief excerpts from the comments of some of the men who guided this approach into legislation (1): "One of the major problems with water quality standards was... the fact that they were unenforceable." "The reason why water quality standards were not enforceable is that, at that time, and I think it is still true today, it was impossible to infer from stream characteristics, water quality, goals, standards... a specific level of control for an individual source... the water quality standards concept, the way the engineering community had used the concept, depended on some societal judgment about the beneficial use of the waters." "By and large water quality standards were measured in terms of four pollutants -- biochemical oxygen demand, suspended solids, fecal coliform, and pH. There was a growing recognition in 1972 that they weren't sufficient." Freeman (22) observes that technology-based standards are usually perceived as simplifying matters. A less kind observation might paraphrase the attitude as, "It's too hard to do it right, so let's not even try."

The other pressures leading to the adoption of technology-based standards were more political and related to the specific conditions in the U.S. in 1972. Again, these same Congressional staffers: "...there were a number of things that were going on in the area of water pollution control that set the stage for another

congressional look at the subject. Among these was the concern that abatement was not proceeding at the pace that anybody would consider acceptable under the Water Quality Act of 1965... Another perception was more a function of the general political climate of that time. Earth Day... brought about a general concern that the government at all levels was not doing enough for environmental quality... Another feature was a continual expression of concern that the states were simply not strong enough to take meaningful action against the entities of economic power... On the construction grants side... the evidence.. was beginning to accumulate that the assistance program was not of sufficient magnitude..."

While some of the motivation came from the philosophical position that disposal of wastes is not a legitimate "use" for water resources, by far the greatest part seems to have come from the perceived need to adopt an uncomplicated approach that would produce results -- fast.

How has it worked? Apparently, not too well. According to Freeman (22), the benefits claimed for this approach have been largely illusory. From the standpoint of how quickly water quality was improved, he says, this approach was not necessarily more successful than the water-quality-based approach because it has had its own problems in information gathering, procedural delays, and legal challenges. Language such as "best practical" and "reasonable cost" leaves a great deal to administrative discretion and leaves the door open to bargaining. Numerous issues have arisen: Should "exemplary" plants or a cross section of existing plants be used to determine "practicable" standards? Should guidelines give specific numerical values? Should in-plant process changes be considered? So much for simplicity and quick results.

Another difficulty is that technology-based standards discourage innovation in treatment processes and encourage reliance on the prescribed technologies even when they seem unlikely to produce the desired quality of effluent. The latter is a particularly important point from the standpoint of enforcement, because a discharger that can demonstrate that in good faith it relied on the required technology is in a fairly safe position even should its effluent cause identifiable problems.

Freeman also feels that this approach is "wanting" in terms of economic efficiency, that "the strategy is a step in the wrong direction in that it breaks the link

between resource expenditure and environmental objectives." Even those who agree philosophically with the pollution-elimination direction of the approach, such as Westman (23), point out that the implementation is lacking in cost-effectiveness. This is a critical disadvantage, especially in current less-than-healthy economic circumstances.

It seems that the pendulum is about to swing back toward a more quality-based approach. As Moore (24) said, "While reading the Environmental Protection Agency's recently published 1990 Strategy, I experienced a sense of 'deja vu.' Seems we have been there before -- with all the references to reliance on water quality standards as the basis for the level of control to be required. It is indeed the quality of the water that should be the measure of progress."

CHAPTER 2

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CHAPTER 3 LEGISLATION AND GUIDELINES

ALBERTA

Alberta deals with air and water under separate statutes, the Clean Air Act (1) and the Clean Water Act (2). Land pollution is covered by the provisions of several statutes, including the Public Health Act (3), the Municipal Government Act (4), the Public Lands Act (4.1), and the Land Surface Conservation and Reclamation Act (5). The latter gives Alberta Environment wide authority to undertake various resource planning activities and provides the authority for assessment of potential environmental and community impacts of activities likely to result in "surface disturbance".

The general scheme of the Clean Air and Clean Water Acts is similar. Construction of specific types of plants and facilities likely to produce either air or water contaminants is prohibited without a permit from the Alberta Environment Director of Standards and Approvals. Conditions setting maximum permissible contaminant concentrations, as well as testing, monitoring and reporting requirements may be included in permits. Following construction, plant operation is prohibited without a "licence to operate" from the Director of Standards and Approvals. The Minister has a discretion to issue "certificates of variance" that may contain standards likely to produce contaminant emissions in excess of any of the air contaminant emission standards or in excess of standards specified in water quality guidelines or criteria issued under the Clean Water Act. The Director of Pollution Control has a discretion to issue "emission control orders" or "water quality control orders" when it appears to him that:

1. Any of the maximum permissible concentrations specified in the regulations is or is likely to be exceeded;
2. a contaminant with an "offensive odour" or in the case of water, a "disagreeable appearance", is being emitted;
3. a term or a condition of a licence is or is likely to be contravened;
4. a contaminant exists that is or is likely to be detrimental to life or health or to adversely affect property.

"Stop orders" may be issued by the Minister of Environment if he is satisfied that there is either an immediate danger

to human life or property or failure to comply with the Act, Regulations or the terms of a Director's order or direction.

The Energy Resources Conservation Board uses Alberta Environment Clean Air Act and Clean Water Act standards and guidelines in exercising its powers to recommend approval of energy developments under the Oil and Gas Conservation Act (6), the Pipeline Act (7), the Coal Conservation Act (8), and the Hydro and Electric Energy Act (9). Applications are referred for review and recommendations by the Minister of Environment. There is considerable cooperation between the Board and the Department of Environment. For example, senior department officials have sat on ERCB application hearing panels as acting Board members, and department staff have advised the Board or cross-examined applicants on environmental matters at hearings (10). Information guides for applicants, such as "Sour Gas Processing Plant Applications to the ERCB, A Guide to Content" (11), are issued under the authority of both the Deputy Minister of Alberta Environment and the Chairman of the ERCB.

Certain important standards, such as the sulphur recovery guidelines (12), are issued as ERCB Informational Letters or Interim Directives. Authority to inspect and to issue emission control orders in relation to natural gas processing plants (13) and thermal electric power plants (14) is formally delegated to the ERCB by the Minister of Environment.

Air

"Air Contaminant" is defined by the Clean Air Act to include any substance in the atmosphere resulting directly or indirectly from the activities of man. "Air pollution" is the presence in the atmosphere of any air contaminant in excess of maximum permissible levels prescribed by regulation or the presence in the atmosphere of any offensive odour.

Ambient air quality standards are established for sulphur dioxide, hydrogen sulphide, nitrogen dioxide, carbon monoxide, oxidants, suspended particulates, and total dust fall by the Clean Air (Maximum Levels) Regulations (15). Since no offence provision relates to these "maximum permissible concentration(s)" of air contaminants in ambient air, they are not directly enforceable. An exception is s. 9.040 of the Oil and Gas Conservation Regulations (21) which requires that the operator of a gas processing plant shall conduct operations so as to maintain the average maximum ambient concentration of any contaminant within the maximum

permissible concentrations set out in the Clean Air (Maximum Levels) Regulations. Breach is an offence under s. 139 of the Oil and Gas Conservation Act (6).

The Maximum Levels Regulations also state that the "maximum permissible visible emissions permitted to be emitted anywhere in Alberta from any stationary source of air pollution . . . shall not exceed an opacity of 40% averaged over a period of six consecutive minutes." Particulates in effluent streams to the atmosphere are not to exceed specified concentrations expressed in lbs./1000 lbs. of effluent resulting from specified manufacturing processes. In a separate part, the Regulations provide that particulate emissions from secondary lead smelters "shall not exceed" specified concentrations expressed in grams per normal cubic meter of effluent. However these emission standards may be exceeded for stated periods of time in the event of equipment malfunction or breakdown. Another separate part of the regulations provides that quantities of "vinyl chloride in an effluent stream to the atmosphere" from vinyl chloride and polyvinyl chloride plants "shall not exceed" listed values.

Effluent discharge standards for other contaminants are not stated in The Act or the Regulations. Section 4 of the Clean Air (General) Regulations(16) empowers the Department to issue air contaminant emission guidelines.

Guidelines have been issued for fertilizer plants and related industries (17). Emission levels in pounds per short ton of product produced are prescribed for contaminants produced by new and existing (by specified dates) plants of the following types: sulphuric acid, nitric acid, phosphoric acid, urea synthesis, urea prilling or granulation, ammonium nitrate prilling, ammonium phosphate, phosphate rock grinding, ammonium nitrate, and ammonia synthesis. Major contaminants include SO₂, NO_x, SO₃ and mist (as H₂SO₄), soluble fluorides (as HF), free ammonia, and particulates. Maximum cumulative half hour ground level concentrations that take entire plant complexes into consideration are prescribed. Maximum ambient values are expressed for certain contaminants only. For SO₂ and NO_x the Clean Air (Maximum Levels) Regulations are incorporated. The guidelines include recommendations on plant design, abatement equipment, operation, and testing. This is in terms of "best demonstrated technology", i.e. control technology currently in successful use in a commercial installation.

Sulphur recovery guidelines for gas processing operations(84) have been jointly published by Alberta

Environment and the Energy Resources Conservation Board. The Board applies these guidelines in assessing applications for natural gas processing plant permits under the Oil and Gas Conservation Act. For new plants (construction commenced after December 1, 1980) producing more than 10 tonnes of sulphur per day, required recovery begins at 94.5% and increases to a maximum of 99% for 2500 or more tonnes per day of sulphur produced.

Guidelines for the location of bulk ammonia storage facilities(18) include recommendations on minimum distances for various capacity tanks from residential buildings. There are also certain design stipulations.

Environmental Guidelines for Asphalt Paving Plants(19) include stipulations for installation of dust control equipment on dryer exhaust systems to reduce particulate emissions to the level specified in the Clean Air (Maximum Levels) Regulations. There are also stack design criteria and stack monitoring and reporting requirements.

Incinerator "standards"(20) have also been issued. These are not designated guidelines and are more in the nature of a manual of incinerator design, installation and operation.

Provisions of the Clean Air (General) Regulations make it an offence to exceed the visible emission or particulate emission standards prescribed by the Clean Air (Maximum Levels) Regulations. It is also an offence to release a toxic air contaminant without the written approval of the Director of Standards and Approvals(16a). The Maximum Levels Regulations emission standards for secondary lead smelters and vinyl chloride plants are enforceable under the Clean Air Act general penalty provision or under the licence contravention provision if incorporated in licences as terms or conditions.

Major offences in the Clean Air Act and Regulations are:

1. Operating without a licence or "in contravention of a term, condition or requirement of a licence";
2. Contravention of a term, condition or requirement of a certificate of variance(1b);
3. Failure to comply with an emission control order (1c); and
4. Failure to report an "uncontrolled release" not authorized by a licence(16b).

Water

Unlike the Clean Air Act, the Clean Water Act and Regulations contains neither maximum permissible ambient concentrations, nor effluent discharge standards for particular contaminants. Section 6 of the Clean Water (General) Regulations(22) does permit the issuance of effluent guidelines. Under this authority the following guidelines have been issued:

1. Waste Water Effluent Guidelines for Alberta Petroleum Refineries, August 16, 1976.
2. Gas Processing Plants Waste Water Management Standards, September, 1973.
3. Waste Water Effluent Guidelines for Alberta Fertilizer Plants, October 16, 1976.
4. Guidelines for Alberta Brine Storage Reservoirs, March 1, 1978.
5. Environmental Control Guidelines for Asphalt Paving Plants, March, 1977 (also issued in accordance with s. 4 of the Clean Air (General Regulations)).

Waste Water Effluent Guidelines for Alberta Petroleum Refineries emphasize in-plant recycling of waste waters. It is stated that the Federal guidelines should be utilized as minimum baseline standards. Oil and grease content of once-through-cooling-water discharge is limited to 5 mg/l. For storm water runoff, permitted deposits of oil and grease, phenols and total suspended matter are expressed as a discharge rate (lbs./10,000 gal.) and a discharge limit (lbs./mo./1000 bbls./day).

Maximum emission rates and concentrations of contaminants in the liquid effluent from refineries are not to exceed specified values. Values are given for chemical oxygen demand, oil and grease, total suspended solids, phenols, sulphide, ammonia nitrogen, threshold odour number and pH. They are expressed as maximum daily, one day and monthly amounts (lbs./1000 bbls. of crude oil processed per day), and as average concentrations based on best practicable technology and a nominal effluent flow rate.

Values are provided for refineries with and without disposal well capability. The guidelines are not intended to encourage deep-well disposal, which is regulated by the

Energy Resources Conservation Board. The alternatives of surface treatment and discharge and deep-well disposal are evaluated for each specific site.

The Guidelines also include testing methodology and monitoring and reporting requirements. Effluent objectives are prescribed for the following toxic elements: chromium, cyanide, lead, mercury, zinc, nickel. Toxicity testing schedules and procedures in the Federal guidelines are stated to apply.

Gas processing plants are classified by the Waste Water Management Standards as A, B or C depending on whether sweet or sour gas is processed, whether or not sulphur is recovered, and whether or not waste water is discharged to watercourses. For example, Class A plants process sweet or sour gas, do not recover sulphur and do not discharge waste water. For new or existing Class A and B plants approval is based on zero discharge of waste water to surrounding watershed areas. If disposal is by deep-well injection there must be compliance with the regulations administered by the Energy Resources Conservation Board.

Emission standards are prescribed for process waste water discharge by Class C plants and for surface runoff from Class B and C plants. In both cases parameters are chemical oxygen demand, total suspended solids, total sulphide, ammonia nitrogen, oil and grease, threshold odour number, and pH. All emission rates except the latter two for process waste waters are based on the quantity of raw gas charged to processing units.

For surface runoff waters emission rates are expressed as loadings in terms of lbs./day based on a discharge of 100,000 gal./day. Concentrations in both cases are expressed as mg/l.

Standards for 15 toxic elements are listed. Toxicity testing is prescribed with reference to Standard Methods as modified by the Department's Biomonitoring Guidelines and Standards. Testing, monitoring and reporting requirements are also included. Detailed conditions of operation for Class A, B and C plants that are intended to be incorporated into operating licences are included as appendices.

The Fertilizer Plant Waste Water Effluent Guidelines are based on best demonstrated technology for each individual processing unit. Limits are expressed as permitted pounds of contaminant discharge per ton of production, and permitted gallons of waste water per ton of production and applied to each process unit.

Emission limits are prescribed for new and existing plants in relation to ammonia-nitrogen, nitrate-nitrogen, organic nitrogen, phosphate (PO_4), total suspended solids, chromium (hexavalent), and pH. Values are listed for daily maximum, one day and monthly amounts in terms of a nominal plant liquid effluent discharge rate. This rate is based on an equivalent reference ammonia manufacturing capacity which is calculated for each type of plant.

Limits in lbs./100,000 gal./day for surface runoff when storm water is discharged are prescribed for ammonia-nitrogen, nitrate-nitrogen, organic-nitrogen, phosphate, total suspended solids and pH. Effluent objectives for six toxic elements are specified. Requirements are also set out for bioassay, sampling and analysis methodology, and effluent monitoring. In-plant and external plant control recommendations are made for various types of plants. Waste water management alternatives including land irrigation, deep-well disposal and gypsum pond disposal are also discussed.

The Brine Storage Reservoir Guidelines provide general recommendations on site selection, pond construction and maintenance, problems and corrective measures, monitoring and reporting. No numerical effluent values are included.

Asphalt Paving Plant Guidelines include general process and control recommendations and requirements for both water and air emissions.

In addition, the Standards and Approvals Division has published Surface Water Quality Objectives(23), and Objectives for Stormwater Management(24). The Surface Water Quality Objectives are the general ambient water standards for Alberta. They were developed cooperatively with Saskatchewan and Manitoba. Values are included for the following parameters: bacteriology, dissolved oxygen, biochemical oxygen demand, suspended solids, pH, temperature, odour, colour, turbidity, organic chemicals (6 constituents), pesticides, toxic chemicals (9 constituents), radioactivity, inorganic chemicals (9 constituents), and unspecified substances.

Since neither the various Guidelines, nor the Objectives are regulations made under regulation-making powers in the Clean Water Act, they are not directly enforceable.

Like the Clean Air Act, the Clean Water Act contains offences designed to enforce the approval system. It is an offence to construct or operate works without a permit or

licence or in contravention of permit or licence terms and conditions(2a), to contravene a term or condition of a certificate of variance(2b) or to fail to comply with a water quality control order(2c). However it is also an offence to deposit or permit the deposit of a water contaminant in water or where it may enter water if it is likely to degrade or alter the chemical or biological quality of water so it is likely to be rendered harmful to human health, fish, wildlife, livestock or plants(2d).

Land

Under the Municipal Government Act, authority to collect waste, to operate land disposal facilities, and to pass bylaws relating to the collection and disposal of waste is delegated to municipalities. Waste disposal sites and systems are also subject to the Refuse Disposal System Regulations(25) made under the Public Health Act(3). The regulations divide disposal systems into four classes: dry disposal sites, modified landfills, sanitary landfills, and unclassified waste disposal systems.

The Hazardous Chemicals Act(26) gives the Minister of Environment a discretion to prohibit the discharge on land or otherwise of chemical substances that he considers to be hazardous. Nothing has yet been listed in the Schedule of prohibited substances.

Deep-well disposal of waste is regulated by the Energy Resources Conservation Board under the Oil and Gas Conservation Act(6a) and Regulations(21).

Following an ECA report and recommendations(27) and other study, the Alberta government enacted legislation to regulate disposal of hazardous waste. This includes amendments to the Hazardous Chemicals Act(81) and the new Special Waste Management Corporation Act(82) and the Transportation of Dangerous Goods Control Act(83).

No numerical standards are provided for solid or liquid contaminants deposited on land, except to the extent that they may assume the character of air or water contaminants.

CANADA

Air

Under the Clean Air Act(28), Federal air pollution control activity is mainly directed to a leadership and

advisory role in assisting provinces to develop air quality standards that may be enforced under provincial legislation. To this end "national" Ambient Air Quality Objectives(29) for sulphur dioxide, suspended particulate matter, carbon monoxide, oxidants and nitrogen dioxide have been developed by Environment Canada in consultation with provincial officials through a federal-provincial air pollution committee. Three levels are specified: "maximum desirable", "maximum acceptable", and "maximum tolerable". The meaning of these terms is discussed in Chapter 5. Since no offence provision relates to these objectives, they are not directly enforceable.

The Act also authorizes the Federal cabinet to publish "National Emission Guidelines". These indicate maximum contaminant emission concentrations with reference to particular types or classes of sources. The following guidelines have been published:

1. Thermal Power Generation Emissions - National Guidelines for New Stationary Sources(30);
2. Packaged Incinerators, Emission Guidelines(31);
3. Wood Pulp Industry Emission Guidelines for New Stationary Sources(32).

National Emission Guidelines have no related Clean Air Act offence provision and consequently are not directly enforceable.

Cabinet may also prescribe national emission standards for maximum air contaminant concentrations in emissions from particular classes of stationary sources. This power may be exercised only where emissions would constitute a significant danger to the health of persons or would be likely to result in violation of terms of an international treaty to which Canada is a party. It is a constitutionally tenuous power since it directly and significantly affects provincial resources and public property and "property and civil rights" within provinces(33). National emission standards regulations have been promulgated for vinyl chloride plants(34), asbestos mining and milling operations(34.1), and secondary lead smelters(34.2).

Specific emission standards may be established for Federally regulated works, undertakings or businesses, with the exception of motor vehicles, ships, trains and aircraft. Where relevant national ambient air quality objectives exist, the standard must be based on the "maximum desirable"

level. In the absence of national objectives, standards must be based on best available technology with cost a relevant factor. No regulations of this type have yet been promulgated.

Water

The principal federal water effluent legislation is the Regulations and guidelines that have been promulgated under powers contained in the Fisheries Act(35). These establish liquid effluent requirements for a number of classes of industries. The regulations and guidelines apply only to new industries except in the case of the Chlor-Alkali Mercury Effluent Regulations, which apply to all plants. The Act makes it an offence to deposit any "deleterious substance" in water frequented by fish or water flowing into water frequented by fish. "Deleterious substance" is defined in terms of alteration or degradation of water quality so as to harm fish and impair the use of fish by man. The following regulations have been promulgated; the first three relate to case study industries:

1. Pulp and Paper Effluent Regulations(36). Standards are established for BOD and suspended solids in effluent discharged by existing, expanded or altered kraft, sulphite or semi-chemical pulp mills. "Toxic waste", i.e., any waste found to be toxic according to a prescribed bio-assay procedure, is also regulated. The Regulations will apply to existing mills only when they are amended to insert a date opposite the words "Existing Mills" in Schedule VI.
2. Petroleum Refinery Liquid Effluent Regulations(37). The Regulations and Guidelines came into effect on 30 October 1973. The guidelines apply to refineries that were in operation on that day and the regulations apply to those that started operation after that day.

The existing Petroleum Refinery Liquid Effluent Guidelines (38) contain a set of enforceable standards for deleterious substances discharged in effluents from petroleum refineries: oil and grease, phenols, sulfides, ammonia-nitrogen, suspended matter and any substance capable of altering the pH of liquid effluent and once through cooling water. The guidelines contain a set of unenforceable standards for the same substances.

Guidelines respecting acute toxicity of liquid effluents from petroleum refineries and from existing petroleum refineries(39) set a standard for the toxicity of the effluents. The regulations and guidelines establish requirements to measure and report to the minister all controlled parameters.

3. Chlor-Alkali Mercury Liquid Effluent Regulations(40). Chlor-Alkali Mercury Liquid Effluent Regulations prohibit owners of designated plants from discharging mercury in excess of .00250 Kg per tonne of chlorine times the defined reference production rate of the particular plant. Plant owners are required to install and maintain specified sampling facilities, take and analyze samples in the prescribed manner, and file regular reports with Environment Canada.
4. Potato Processing Plant Liquid Effluent Regulations and Guidelines(41).
5. Metal Mining Liquid Effluent Regulations and Guidelines(42).
6. Poultry Processing Liquid Effluent Regulations; Meat and Poultry Products Plant Liquid Effluent Regulations and Guidelines(43).
7. Fish Processing Operations Liquid Effluent Guidelines(43a).
8. Metal Finishing Liquid Effluent Guidelines(43b).

All of these regulation standards can be enforced by prosecution under section 33 of the Fisheries Act.

In the Yukon and Northwest Territories the Fisheries Act water quality provisions are supplemented by the Northern Inland Waters Act(44), the general territorial water use statute. Deposit of waste in or near any waters is prohibited except in accordance with a licence or as authorized by regulation. "Waste" is defined in terms similar to the Fisheries Act. Water licences issued by the Territorial Water Boards may contain conditions establishing maximum permissible contaminant concentrations in effluent discharged to waters. However, such conditions must not conflict with waste discharge standards established under the Canada Water Act(45) or with standards imposed under the Fisheries Act or Regulations.

The Canada Water Act provides for water quality management authorities under agreements with provinces, and in the case of "interjurisdictional waters" for unilateral federal establishment of water quality management agencies. A number of cooperative federal-provincial basin studies have been carried out under the Act. But federal-provincial relations factors have prevented the establishment of any water quality management areas. Consequently the offence of adding "waste" (defined in terms similar to "deleterious substance" in the Fisheries Act) to waters in a water quality management area is without legal force.

Only one set of specific standards has been promulgated under the Act. Under the Phosphorus Concentration Control Regulations(46), concentration of prescribed nutrients in laundry detergents shall not exceed 5% by weight expressed as phosphorus pentoxide and 2.2% by weight expressed as elemental phosphorus.

ONTARIO

The principal air pollution control statute is the Environmental Protection Act, 1971(47) (EPA). Water pollution control jurisdiction is vested in the Minister of the Environment by the Ontario Water Resources Act(48). However, the general offence provision in the EPA that prohibits the discharge of contaminants into the natural environment(47a) also applies to water contamination. Certain specific water pollution regulations such as those concerning discharge of sewage by pleasure boats(49) have also been brought under the EPA. Land waste disposal sites and systems are regulated under the Environmental Protection Act.

Air

Under the Environmental Protection Act, discharge or emission of contaminants into the natural environment is prohibited. "Contaminant" includes any solid, liquid, gas, odour, heat, sound, vibration, radiation or combination, and is defined in terms of impairment of the quality of the natural environment for any use that can be made of it, injury or damage to plants, animals or property and effects on human health, safety and comfort. This prohibition extends to discharge of contaminants in excess of amounts, concentrations or levels prescribed by the regulations. Contravention of this provision is an offence punishable upon summary conviction by a fine of up to \$5000 for a first offence and up to \$10,000 for subsequent offences. Each day is deemed to be a separate offence.

There is also an approval system. A certificate of approval from The Director of the Air Management Branch of the Ministry of Environment is required to construct, alter or extend any works or equipment (with certain specified exceptions) likely to emit any air contaminant into the natural environment. Program approvals for programs designed to prevent or to reduce and control emission of air contaminants may also be issued by the Director. Specific requirements and time frame are negotiated by Ministry of the Environment regional officials. The objective of program approval requirements is to obtain compliance with contaminant emission standards or to achieve ambient objective levels within a specified time period.

A program approval, unlike a certificate of approval, provides immunity from prosecution in respect of any matter covered by the approval. However, a program approval is a defence to a charge only if there has been full compliance with its terms.

The Director is authorized to issue control orders upon findings in the report of a provincial officer that section 17, the principal pollution offence provision, is being contravened or that standards established by regulation are being exceeded. This power may be exercised notwithstanding the existence of a program approval. Control orders have been issued to entire industries, such as the pulp and paper industry. The objective is to upgrade emissions by means of sequential control orders that impose progressively more onerous treatment requirements.

Stop orders may be issued where the Director is of the opinion, on reasonable and probable grounds, that it is necessary to protect or conserve the natural environment or to prevent or control an immediate danger to human life, the health of persons, or property. The decision to issue a stop order is not entirely a subjective discretionary power. It has been held by The Ontario Supreme Court that these decisions must have an objective evidentiary basis(80). This judicial scrutiny of stop order decisions has caused stop orders to be infrequently used.

Air Pollution Control (General) Regulations(50) set out in a schedule the maximum concentration of contaminants and related substances from a source on a one half hour average basis, at a specified "point of impingement" on a receptor of the contaminant emission stream. It is an offence to exceed the standards prescribed in the schedule. There is also a general prohibition in the Regulations directed to emission of air contaminants to such an extent or degree as may:

- (a) cause discomfort to persons;
- (b) cause loss of enjoyment of normal use of property;
- (c) interfere with normal conduct of business; or
- (d) cause damage to property.

Offences based on a prescribed visible emission chart are also established. The Regulations authorize development of an Air Pollution Control Index and empower the Minister to order emergency curtailment of operations when specified Index levels are reached. A specific enforceable standard for carbon content of organic material emitted as a result of incinerator operation is also prescribed.

Desirable ambient air quality criteria for 23 contaminants are set out in the Ambient Air Quality Criteria Regulation(51). These ambient criteria are not made directly enforceable.

Specific enforceable standards for solid material emissions from asphalt paving plants are established by the Asphalt Paving Plants Regulations(52). Enforceable standards are also prescribed for particulate and other air contaminant emissions from certain ferrous foundries (53). Maximum sulphur contents of coal and fuel oil in the Toronto area is set out in the Sulphur Contents of Fuels Regulations(54). These latter standards are also enforceable.

Where insufficient information is available to permit development of an ambient objective and an emission standard for a particular contaminant the Ministry publishes "guideline", "provisional", or "tentative" ambient objectives (24 hour) and corresponding half hour average point of impingement emission limits based on available data. These values are unenforceable. However as knowledge improves these provisional, guideline and tentative values may be upgraded to ambient objectives and enforceable emission standards under the regulations.

Unenforceable Guidelines for the Control of Industrial Phosphorus Discharges in Liquid Effluents (October, 1976) have been issued. The purpose is stated to be to assist Ministry staff in their abatement and approvals functions and also to give industry "an indication of environmental control requirements".

Water

The Ontario Water Resources Act (48) gives the Minister of the Environment management powers over all surface and ground waters. Major water uses (over 10,000 gal./day) are regulated under a permit system.

There is no general permit or approval scheme for regulation of contaminant discharges to water. However, certificates of approval must be obtained for construction and operation of water or sewage treatment plants. Directors under the Act are empowered to make orders regulating or prohibiting the discharge of sewage into waters. Failure to comply with such orders is an offence(48a). Directions or requirements may be issued against industrial or commercial enterprises that make sewage treatment or disposal arrangements that are considered unsatisfactory by the Director. Contravention of such directions or requirements is an offence(48b).

There is a general prohibition, backed by a quasi-criminal sanction, of discharge into any waters of polluting material that "may impair the quality of the water"(48c). Each day of contravention is a separate offence punishable by a fine of up to \$5000 on first conviction, and a fine of up to \$10,000 or imprisonment for up to one year, or both, for each subsequent conviction.

The Minister is also empowered to bring actions for injunctions to restrain any contravention of the Act or regulations or of any order or direction(48d).

To assist Ministry officials in their water management functions a "Blue Book"(55), outlining goals, objectives and policies, has been issued. Ground water quality criteria are also included. Ontario is the only study jurisdiction to explicitly include ground water in its quality objectives.

The Blue Book also sets out ambient water quality objectives for temperature, turbidity and for concentrations of alkalinity and pH, ammonia, chlorine, cyanide, dissolved gases, dissolved oxygen, hydrogen sulphide, oil and grease, phenols, phosphorus, radionuclides, total suspended solids, arsenic, beryllium, cadmium, chromium, copper, iron, lead, mercury, nickel, selenium, silver, zinc, unspecified non-persistent toxic substances and complex effluents, pesticides (22 types) and industrial organics (5 types). These criteria are not directly enforceable, but are stated to be "often the starting point in deriving waste effluent requirements" that are incorporated in certificates of approval and program approvals. The objectives represent "minimum water quality conditions".

Two types of hazardous substances are identified in the Blue Book: those with zero tolerance limits, and those with undefined tolerance limits. Those in the first category (5 are listed) are to be prohibited or emission reduced to the

"lowest practicable levels". Substances with undefined tolerance limits (44 are listed) are those for which there are insufficient scientific data to establish water quality objectives. For these latter substances, release is to be "evaluated on a case by case basis, and special measures" adopted.

Objectives for the Control of Industrial Waste Discharges(56) have also been issued by the Ministry of the Environment. These are not directly enforceable, but are used as requirements in the issuance of certificates of approval. They outline "desirable effluent discharge characteristics" for BOD, suspended solids, oil and grease, metals, phenols, toxic substances, ammonia, pH, sulphate, chlorides and dissolved solids, taste and odour, temperature, and aesthetic qualities.

Land

No waste management system including collection, handling, transportation, storage, processing and disposal may be operated without a certificate of approval from the Director(47b). A public hearing by the Environmental Assessment Board is required for proposed facilities designed to handle more than the equivalent domestic waste of 1500 persons.

Specific standards for land discharge of contaminants have not been developed. However the standards, criteria and guidelines for air and water contaminants apply where relevant. Design and operational guidelines for landfill sites(57) have been published. These are not directly enforceable.

The Transfers of Liquid Industrial Waste Regulation(58) establishes a waybill control system for transportation of liquid industrial waste. A classification guideline for hauled liquid industrial wastes(59) has also been developed. Guidelines for land disposal of sludge(60) have been issued. "Liquid industrial waste" has been defined broadly in the Regulation(58) to include virtually anything that is moved in a tanker. The regulation is now being revised to narrow its target to hazardous, as opposed to relatively innocuous liquid waste, or "waste" from one industry that may become an input in another industrial process.

SASKATCHEWAN

The Air Pollution Control Act(61) and the Air Pollution Control Regulations(62) establish a permit system to regulate new (post-1975) air contaminant sources. The Minister of the Environment is empowered to make certain remedial orders. Municipalities are authorized to pass air pollution bylaws. Contaminants produced by livestock operations, oil and gas activities and mineral industry operations are regulated outside the permit system under special acts and regulations.

Water contamination comes within the Minister of the Environment's powers to manage water and sewage works and to control pollution under the Water Resources Management Act(63). There are approval powers for water and sewage works. Principal pollution control powers are those authorizing the Minister to issue orders prohibiting discharge of water contaminants.

Powers to investigate and to issue stop orders are conferred upon the Minister by the Department of the Environment Act(64). However, neither this Act nor the Air Pollution Control Act nor the Water Resources Management Act contains powers to issue conditioned control orders such as those in the Ontario and Alberta statutes. The Department of the Environment Act also empowers cabinet to make regulations concerning various aspects of land disposal of contaminants. Environmental Spill Control Regulations(65) designed to remedy spills of specified contaminants have been promulgated.

Air

Ambient air quality "standards" for suspended particulates, settleable particulates, soil index, potash, sulphur dioxide, sulphation, carbon monoxide, oxidants (ozone) and nitrogen dioxide have been made under the Air Pollution Control Regulations(62). These ambient standards are made directly enforceable. Operation of any industrial source, incinerator or fuel-burning equipment that results in discharge of air contaminants, alone or in combination with the same contaminant from another source, that causes a concentration of an air contaminant in excess of the prescribed ambient standard for that contaminant, is prohibited(62a). Contravention makes an individual liable upon summary conviction to a fine of up to \$500 and \$50 for each day the offence continues and corporations liable to fines of up to \$5000 and \$500 respectively(61a).

Discharge of any air contaminant or odour that may "cause discomfort to or endanger the health, safety or welfare of persons, cause loss of enjoyment to normal use of property, interfere with normal business, or cause damage to property", is also prohibited^(62b). It is an offence to discharge hydrogen sulphide gas into the atmosphere^(62c) and to discharge any visible air contaminant that exhibits an opacity greater than^(62d)40%. Burning of trash in other than an approved manner is also prohibited.

The permit requirement under the regulations does not apply to industrial sources that are subject to the provisions of the Pollution (By Livestock) Control Act, 1971(66); the Oil and Gas Conservation Act, 1969(67); or the Pollution Prevention Regulations for the Mineral Industry, 1970(68). In the case of contaminant sources in existence prior to promulgation of the Air Pollution Control Regulations in 1975, a permit is required only when the Minister, by Gazette notice, requires a permit to be obtained. Equipment for heating, road construction, and agricultural operations is exempt. Permit terms and conditions may be imposed to specify control equipment required, establish ambient or emission standards for particular sources, and specify testing and measurement to be carried out. Uncontrolled releases of any contaminants must be reported within specified time periods. Failure to do so is an offence.

Under the Pollution Prevention Regulations for the Mineral Industry, no industrial waste may be discharged into the environment without the Minister's approval. Criteria established by regulations under the Air Pollution Control Act are to be used as a guide to determine "the allowable discharge of industrial wastes into the outdoor atmosphere". A chart of "Provisional Maximum Quantities of certain Solids and Gases in the Outdoor Atmosphere Permissible Under The Regulations for 1970" is established for suspended particulates, settleable particulates, soil index, potash, fluorides, hydrogen sulphide, sulphur dioxide, chlorine and nitrogen dioxide.

Water

Ministerial approval is required for major sewage works. It is an offence to discharge "any substance capable of changing the quality of water or causing water pollution"^(63a). The Minister may issue orders prohibiting discharge of any substance "that, in his opinion" is capable of changing the quality of water or causing water pollution^(63b). Such orders have the effect of suspending or varying the terms of affected certificates of approval.

For guidance in the exercise of these powers ambient Water Quality Objectives(69) were issued in February, 1977. The document states that in consideration of applications to build new works or to improve existing works the Department "will be guided by the water quality objectives".

Surface water quality objectives have been stated for the following parameters: bacteriology, dissolved oxygen, biochemical oxygen demand, suspended solids, pH, temperature, odour, colour, turbidity, organic chemicals (six constituents), inorganic chemicals (ten constituents), toxic chemicals (nine constituents), and unspecified substances. Also included are objectives for algae and aquatic nuisances, specific municipal drinking water objectives, objectives for ground water quality, and sewage treatment guidelines for primary and secondary treatment.

These objectives are not directly enforceable except to the extent that they are incorporated as conditions of permits or as terms of ministerial prohibitory orders. It is also likely that they will be considered relevant in defining the standard in the general offence provision - "capable of changing the quality of water or causing water pollution".

Land

Under the Department of the Environment Act, the Cabinet may make regulations to control the disposal of solid wastes into the environment. However, at present solid waste disposal is regulated by the Department of Health under the Public Health Act(70). Negotiations are underway to bring industrial landfill sites under the jurisdiction of the Department of the Environment. An interdepartmental task force is preparing recommendations on hazardous waste disposal. Environmental Spill Control Regulations(65) have been made under the Department of the Environment Act.

Land disposal of liquid and solid tailings and other industrial waste is regulated by the Pollution Prevention Regulations for the Mineral Industry, 1970. Written approval of the Minister is required for any discharge of industrial waste into the physical environment of a mine or plant. "Provisional maximum" concentrations are established for the following solids: settleable particulates, suspended solids, soil index and potash. These maximums are not directly enforceable.

BRITISH COLUMBIA

The British Columbia legislative framework for setting and enforcing environmental standards is in a state of flux. The Environment Management Act(71) gives the Minister wide powers to require environmental assessments, to make "environmental protection orders", to implement environmental emergency measures, and to order inquiries. There is also provision for establishment of an Environmental Appeal Board which has assumed functions formerly exercised by the Pollution Control Board.

This is merely the first in a series of proposed changes. A major step will see the Pollution Control Act replaced by the proposed Waste Management Act. The result is that the system is difficult to describe at present. It is not clear what features of the present system will be continued when the new legislation is fully implemented. We have chosen to describe the "old" system currently in force under the Pollution Control Act with its standard setting public inquiry feature. However, it is possible that environmental standards will never again be reviewed publicly under the new system.

Contaminant discharges to air, water and land are regulated under the Pollution Control Act(72). Discharge of any "contaminant" into air and any effluent or other waste into water is prohibited without a permit or approval from the Director of The Pollution Control Branch. "Contaminant" is defined to include any substance that is foreign to or in excess of the natural constituents of air that affects the natural, physical, chemical or biological quality of air and that is or may be injurious to health, safety or comfort of persons, damaging or injurious to property or plant life, tend to interfere with visibility so as to hamper business or transport, or generally be obnoxious to the public. "Effluent" means any deleterious material flowing out of a drain, sewer, outfall or sewage disposal system or works.

Discharge without a permit or breach of the terms or conditions of a permit is an offence. Punishment upon conviction is a fine of up to \$10,000 or one year imprisonment, or both for a first offence, and up to \$500 per day for each day the offence is continued.

In a process unique to British Columbia, pollution control objectives for discharge of particular contaminants have been established following a series of public inquiries by panels headed by the Director. These objectives have

been formulated on an industry-by-industry basis taking into consideration specific industrial processes and equipment. The following pollution control objectives have been published:

1. Pollution Control Objectives For The Forest Products Industry of British Columbia(73).
2. Pollution Control Objectives For The Chemical and Petroleum Industries of British Columbia(74).
3. Pollution Control Objectives For The Mining, Smelting and Related Industries of British Columbia(75).
4. Pollution Control Objectives for Food Processing, Agriculturally Oriented and Other Miscellaneous Industries(76).
5. Pollution Control Objectives For Municipal Type Waste Discharges(77).

In the case of the Forest Products and Mining and Smelting industries second inquiries have been held after a period of approximately five years, to review and update the original objectives. Guidelines For Assessing Sewerage Works(78) and Minimum Requirements For Refuse Disposal to Land(79) have also been published.

The introduction to the objectives for Mining, Smelting and Related Industries states that the idea of ranges of concentrations is used, for the first time, and

"take(s) account of the needs of particular receiving environments. The more stringent values will apply to sensitive environmental situations, the less stringent where it can be shown that unacceptably deleterious changes will not follow. The Director may designate intermediate values. . . Where two or more discharges share the same receiving environment, the Director will normally limit total discharges so that Receiving Environment Objectives are not exceeded."

Neither objectives, nor guidelines, nor minimum requirements are regulations made under the authority of the

Pollution Control Act. Since the offence provision is limited to contravention of the Act, the regulations and orders, the objectives, guidelines and requirements are not directly enforceable, except to the extent that they are incorporated in permits or approval orders under The Act.

Air

Regulation of air contaminant discharges in the Lower Mainland Region is delegated to the Greater Vancouver Regional District. Municipalities may pass bylaws to regulate emissions from heating and food preparation installations, municipally licenced incinerators, domestic leaf burning, burning for land cleaning, and fires intended for instruction or removal of fire hazards. General municipal pollution or nuisance bylaws are also effective except to the extent that they conflict with the Pollution Control Act and regulations or any permit, approval or order made under it.(72a)

Air Contaminant emissions for various industries are specified in the objectives for each particular industry. For forest products operations, ambient air quality objectives for Level A ("desirable"-applicable to new and altered plants) and Level B ("acceptable"-interim objectives for all other discharges) have been established for sulphur dioxide, total reduced sulphur compounds (measured as H_2S), total suspended particulate matter, total dustfall, and chlorine and chlorine dioxide(73a). Contaminant emission objectives, also at Levels A and B, are specified for thirteen plant operations, processes and treatments(73b). Parameters used include opacity, particulate matter, temperature and various specific contaminants(73b).

Ambient air quality guidelines for the petroleum and chemical industries include Level A, B and C values. The stated intention is that these be used as "minimum objectives" in issuing permits and orders to the industries. Level A will be required for all new operations. Existing operations must meet Level C within the shortest time technically feasible, and must be upgraded to interim Level B and ultimately to Level A. Level A, B and C objectives for oil refineries include parameters for sulphur recovery and sulphur dioxide from the sulphur plant; sulphur trioxide for the overall refinery; particulate solids and sulphur dioxide for steam plants.

Gas treatment plant air emission objectives are in terms of sulphur recovery and acid gas CO_2/H_2S ratio for Levels A, B and C. Level A will be required for all new

plants. Level C is a recovery typically achieved by a plant with two catalytic units, while Level B represents the recovery possible with a three-stage Claus plant. Plants that operate with a $\text{CO}_2/\text{H}_2\text{S}$ ratio of 10:1 or higher may be granted variances on an individual assessment basis.

Objectives for air emissions from petrochemical and paint plants are stated at A, B and C levels for 27 contaminants(74a).

Air emission objectives for chlor-alkali and sodium chlorate plants are stated at A, B and C levels for chlorine, chlorine dioxide, hydrogen chloride, mercury, particulates, lead, sodium chlorate and sodium hydroxide.

Objectives are stated for air emissions from miscellaneous chemical plants. These include A, B and C levels for sulphur dioxide, and sulphur trioxide from sulphuric acid plants, nitrogen oxides from nitric acid plants, total fluoride (as SiF_4 and as HF) from fertilizer plants and inert particulates and monomethylamine from miscellaneous plants.

Ambient air quality objectives for mining, smelting and related industries are stated for sulphur dioxide, asbestos (chrysotile), dustfall, 15 metals and other elements, suspended particulate, and radon daughter concentration. Unlike the original 1973 objectives, the current objectives issued in 1977 do not use A, B and C levels. Objectives are expressed as upper and lower values that define a range of possible concentrations. Emission objectives, again in a range of possible concentrations, are expressed for total particulate, antimony, arsenic, asbestos, cadmium, copper, fluoride, lead, mercury, nitrogen oxides, opacity, sulphur dioxide, and zinc.

Air contaminant emission "control objectives" are also included for parameters relevant to the following industrial processes:

1. Ammonium phosphate fertilizer plants
2. Aluminum reduction
3. Coal-fired power boilers
4. Coke plants
5. Copper smelting
6. Lead smelting and refining, and
7. Zinc smelting.

Discharge concentrations are based on the weight or volume of fuel input or production output. These objectives also provide for a range of concentrations.

Level A, B and C ambient air quality "guidelines" are listed for sulphur dioxide, carbon monoxide, hydrogen sulphide, total suspended particulate, lead, zinc and total dustfall for food processing and certain miscellaneous industries. Level C provides adequate short-term protection of the environment. Level A is intended to ensure adequate long-term protection. Objectives (Levels A, B and C) that apply to air contaminant emissions from all industries in this category include total particulate, lead, sulphur dioxide, nitrogen oxides, hydrocarbons and odours. Particulate emission objectives are provided for certain specific operations including food processing, fermentation and agriculturally oriented industries.

Incineration emission objectives for municipal discharges are expressed in terms of maximum opacity and maximum particulate emission.

Water

Objectives for contaminant discharges to water are included in the pollution control objectives for the various specific industries. Receiving water quality objectives for 21 "characteristics" in terms of degree of change are specified in the Pollution Control Objectives for the Forest Products Industry. Effluent quality objectives in Levels A (desirable) and B (acceptable interim) for suspended solids, BOD₅, pH range, toxicity and certain other relevant characteristics are prescribed for hydraulic debarkers; saw, plane, shingle, wood preserving, veneer and plywood mills; and pulping processes (kraft, sulphite and mechanical). No objectives are established for certain forest industry discharges, such as colour, foaming, fish-flesh tainting, wood waste leachates and salt, for which satisfactory control technology is not available. These characteristics are to be reviewed periodically and interim regulations developed and implemented at the discretion of the Director.

For chemical and petroleum industries, receiving water quality guidelines are prescribed for the following parameters: dissolved oxygen, pH, residual chlorine, turbidity, settleable solids, floatable solids, dissolved solids, heavy metals, phenol, toxicity, and temperature. Effluent quality objectives for 21 characteristics are stated at Levels A, B and C for marine and fresh waters. Effluent characteristics that are closely related to production - oil, BOD, phenols, sulphides, mercaptans and ammonia - are expressed as lbs./1000 bbls. of crude oil processed. Toxicity requirements are based on bioassays conducted on salmon fry, since salmon is both a sensitive and a valuable species.

Effluent quality objectives for 35 parameters are set out for discharges to marine and fresh waters by chemical industries other than petroleum refineries. These industries include natural gas treatment plants, petrochemical industries, resin and paint industries, chlor-alkali and sodium chlorate industries, and miscellaneous chemical industries. In the objectives it is noted that the variable nature of effluents from industries such as natural gas treatment plants precludes establishment of objectives based on units of production. Concentrations are specified on the basis of available methods of treatment.

Receiving water objectives for the mining and smelting industries are established for dissolved oxygen, temperature, turbidity, floatable solids, pH, toxicity (96 hr. bioassay), colour, aesthetics, alkalinity, chloride, and fecal coliforms. Levels are expressed in a variety of ways including numerical values (e.g., chloride - not more than 25 mg/l), percentage of natural or seasonal value (e.g., dissolved oxygen - not less than 90% of seasonal natural value), detectable change (e.g., colour - no change), and Ministry of Health standards (e.g., fecal coliforms - not to exceed Ministry of Health standards).

Mining and smelting industry objectives for discharge of final effluents into marine and fresh waters are stated for total suspended solids, total dissolved solids, toxicity (96 hr. LC50 static bioassay), pH, radioactivity, and 24 metals, other elements and compounds. These objectives, like the mining and smelting industry ambient air control objectives, are expressed in terms of high and low values that define a range of possible discharge concentrations. For example, dissolved solids values range from 2500 to 5000 mg/l dissolved in effluent.

Receiving water quality guidelines for food processing and miscellaneous industries are similar to those for the mining and smelting industries with the following exceptions:

1. a "below detectable limits" guideline is established for chlorine residual.
2. Floatable solids is "negligible increase", as opposed to "none" for mining and smelting industries.
3. colour is "no appreciable change", as opposed to "no change" for mining and smelting industries.

Effluent objectives are stated in A, B and C levels for parameters relevant to the following industries:

1. Fish processing plants,
2. Meat manufacturing processes,
3. Poultry-processing plants,
4. Milk-processing plants,
5. Egg-packing and egg-processing plants,
6. Fruit and vegetable processing plants,
7. Breweries and distilleries,
8. Soft-drink bottling plants,
9. Confined livestock feeding operations,
10. Fish hatcheries,
11. Tanneries,
12. Cement-manufacturing and ready-mix concrete plants,
13. Glass-manufacturing plants,
14. Laundromat and car-wash operations, and
15. Metal-finishing plants and heavy metal discharging industries.

The fish processing plant objectives are for discharge to marine waters only. All others are for discharges to fresh and marine waters.

Most effluent objectives are expressed as a weight of contaminant per unit of production. This takes into account the concentration of contaminant in the effluent and the volume of effluent discharged.

For municipal wastes, receiving water quality maintenance objectives are set for dissolved oxygen, residual chlorine, nutrients, coliforms, toxicity, settleable solids, floatable solids and scum oil, organisms, and heavy metals. Most objectives are in terms of detectable change in condition.

Effluent quality objectives for municipal waste are grouped by category of effluent discharge quantity in terms of average dry weather flow multiples. AA and BB levels are provided for the relevant parameters. This is to differentiate previous A and B level objectives. All new discharges must meet AA levels. Discharges are further grouped by category of receiving water, i.e.:

1. Streams, rivers and estuaries,
2. Lakes, and
3. Marine

Limits (Levels AA and BB) are provided for 29 additional parameters deemed to be of concern in pollution control. These parameters may be included in a permit, and the onus is on applicants to show that these tabulated limits are not likely to be exceeded.

The Guidelines for Assessing Sewerage Works(78) provide design criteria for sewers, pumping stations and sewage treatment plants.

Land

Minimum requirements are stated for refuse disposal to land generally. Refuse is classified in terms of municipal, industrial, and toxic or hazardous waste. Level A, B and C covering frequency requirements are stated in terms of population or population equivalent served.

General objectives are also provided for municipal solid waste landfills. These include landfill location and control objectives based on operating levels. Size criteria are stated in terms of population and refuse quantity. Then operation Levels A-E based on frequency of intermediate cover required are specified for the operation size categories defined.

Minimum objectives of a general nature are provided for disposal of hazardous wastes in municipal landfills. These include thin layer spreading to facilitate absorption, placing hazardous wastes at as high an elevation as possible in the fill, and maintaining records of type, quantity and location of hazardous discharges.

Objectives for contaminant discharges to land by forest products industries include general prescriptions. For example, leachate pollution at disposal sites must be minimized. There is also provision for frequency of cover for specified daily discharge volumes at landfill operations.

General guidelines are stated for disposal of specific types of refuse from chemical and petroleum industries. These include site selection guidelines, and general recommendations for sludges, waste oils and other specified wastes. For example, recovery is stated to be the preferred treatment for organic liquids and solvents. But where this is not practicable, the guideline states that "incineration in properly designed equipment is one alternative." Where available, and provided wastes are acceptable to landfill operators, refuse and solid waste should be taken to municipal or regional landfill sites.

For mining and smelting operations, the following objectives apply to land disposal of putrescible and industrial refuse other than liquid - carried industrial and sanitary wastes, and solids in air emissions:

1. The choice of site and disposal method must minimize potential fire nuisance and leachate pollution.
2. The frequency of covering is to be specified at each site.
3. Open burning is normally prohibited. However, controlled open burning may be allowed on a site-specific basis.
4. The hazardous waste disposal method at each site will be designated by the Director.

In the case of food processing and miscellaneous industries three levels are provided for landfill operations. These are:

1. Level A - daily covering required
2. Level B - covering required at least once every seven days of operation
3. Level C - covering required at least once every 20 days of operation.

General guidelines for landfill site selection and operation are also set out. Special consideration must be given to land disposal of hazardous material and sludge.

Chapter 3

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CHAPTER 4

THE STANDARD SETTING PROCESS

Standard setting processes in the study jurisdictions are reviewed in terms of the "model" outlined in Chapter 2. First the basic model steps - development of goals and objectives; development of criteria; specification of ambient standards; and specification of discharge standards - are considered. Monitoring is discussed in the context of enforcement in Chapter 7.

Because the provincial regulatory systems use permit or licence approvals, a separate section is devoted to how terms of permits are determined. The role of the public in standard setting is also considered separately.

IDENTIFICATION OF GOALS AND OBJECTIVES

In none of the study jurisdictions is goal and objective definition a discrete part of the standard-setting process. Rather this basic first step tends to be lumped with the next two steps - criteria development, and specification of ambient standards.

For water, most "objectives" documents must be carefully read to identify basic goals and objectives. The Alberta and Saskatchewan documents indicate that "it has usually been agreed" that water for public water supply, direct water contact recreation, and aquatic life protection requires the highest quality. Then it is stated that the guidelines are minimum water quality guidelines designed to allow the most sensitive use(1). This was described by officials interviewed as a "universal user" concept.

The British Columbia industry objectives (including air, water and land) refer to maintenance of the environment in as close to its natural state as possible, overall waste reduction, and providing for multiple use of the resource(2).

Federal wastewater effluent requirements are expressed in the Fisheries Act regulations. The basic goal of fish protection is implicit in the authorizing statute. Interviews suggest that while broader environment protection goals may have been more important in early 1970s regulation making,

the current Federal approach focuses more narrowly on fish protection. This is appropriate, since in the meantime provinces have developed greater pollution control capacity.

Only Ontario's "Blue Book" explicitly states goals. The surface water quality goal is:

"to ensure that the surface waters of the province are of a quality which is satisfactory for aquatic life and recreation" (3)

In the case of air, explicit establishment of goals and objectives is even less clear in most jurisdictions. Alberta's ambient standards are in the form of regulations that include no statement of objectives. Only very general health and ecological protection objectives have been identified by commentators (4). The broad statement of purpose in an early Alberta Environment role document, "to promote a balance between resource management, environment protection and the quality of life" has also been noted (4).

Objectives may be inferred from statutory definitions of "air contaminant" and related offence provisions. "Air contaminant" is defined in all jurisdictions in terms of damage to health, safety or comfort of persons, interference with normal business, and damage to property or plant life. In Ontario, the procedure of the Air Standards Setting Committee refers to four basic objectives that are consistent with the Environmental Protection Act definition of "contaminant". These are: protection of 1) human health, 2) animal life, 3) vegetation and 4) property.

Federal ambient air quality objectives appear to have a major influence on provincial goal and objective determination. The Federal objectives are for three levels: maximum desirable (antidegradation for unpolluted areas), maximum acceptable ("realistic" protection for human health and comfort, property, vegetation and animals), and maximum tolerable (abatement is required to avoid long-term risk to human health, comfort or well-being). Provincial officials were involved in the establishment of these standards. Consequently they are used as a point of reference in provinces. For example, Alberta officials state that emission standards generally are based on the Federal maximum desirable objective (4a).

In all cases goals and objectives appear to be determined within government agencies, and particularly within the section

or committee responsible for producing objectives documents. Only British Columbia's industry-by-industry inquiry process involves public input as well as a major role for non-government experts on the standard setting panels. Strict non-degradation objectives are not followed in any jurisdiction. Rather a more pragmatic "effects" approach that takes economic and social factors into account appears to be pursued by the Federal government and the provinces studied(6).

DEVELOPMENT OF CRITERIA

Criteria development is not clearly identified as a discrete standard setting step in any of the study jurisdictions. However, although all provinces use the term "objectives" in the published documents related to water, in fact "objectives" and "criteria" are often used interchangeably. This reflects the fact that objectives (i.e. ambient standards) are often set on the basis of criteria for minimum protection of basic values, such as human health, aquatic life or recreational values. Thus the Ontario Blue Book states that provincial water quality objectives are "a set of narrative and numerical criteria designed for the protection of aquatic life and recreation in and on the water"(3a). The Blue Book also includes drinking water "criteria" and water quality "criteria" for agricultural uses.

Ontario is the only jurisdiction that has formally published scientific criteria along with its objectives. The Rationale For the Establishment of Ontario Provincial Water Quality Objectives(7) contains scientific rationales based on relevant literature for each of the Blue Book objectives. Other provinces clearly devote considerable inhouse effort to criteria development. This is done mainly on the basis of literature reviews. However officials in Alberta, Ontario and Environment Canada indicated that some internal research relevant to criteria determination is conducted.

Similarly in the case of air, the Ontario "Procedure for the Operation of the Environmental Air Standards Setting Committee" uses the term "criteria" when referring to ambient air quality standards(5a). However, the description of Committee organization and operations, in which representatives from various sections advise on effects of values within their particular expertise, suggests that development of technical criteria is very much part of the Ontario process(6a). Data sheets are prepared for particular contaminants showing evaluation of effects on the four basic objectives (human health, animals, property and vegetation) in terms of a limiting time(6b).

In the case of solid waste, a different type of "criteria" is established in most jurisdictions. Design "criteria" related to such matters as site selection, ground and surface water hydrology, gas generation control, and cover material have been developed. British Columbia has published formal "objectives". Ontario has published "guidelines".

SPECIFICATION OF AMBIENT STANDARDS

All provinces studied have compilations that can be characterized as "ambient standards" for both air and water. Unenforceable objectives (Alberta, Saskatchewan, Ontario, Canada Federal) are the norm for water. British Columbia has ambient standards on an industry basis that are also not directly enforceable.

Processes for establishment of ambient water standards are generally similar in all jurisdictions. Basically they are inhouse technical operations to determine values that will protect sensitive uses as described above in relation to water quality criteria. Ambient standards of other jurisdictions are usually closely examined, and often adopted. Prime candidates for adoption by provinces are U.S. Environmental Protection Agency (EPA) standards, International Joint Commission (IJC) Great Lakes Agreement standards(8), and Canadian Federal values. For example, one Ontario Ministry of the Environment official has calculated that of 52 Ontario Blue Book parameters, 38% are based on EPA "Red Book" or "Blue Book" values, 54% are IJC Great Lakes objectives, and 7% are Ontario Environment originated or modified(9). The Federal industry-government task force technique for development of Fisheries Act regulations emphasizes specification of emission standards. Only British Columbia's inquiry approach includes formal public involvement in establishment of ambient water standards.

Generally the very significant judgmental step in specifying ambient water standards is not emphasized. The three steps of identifying objectives, developing criteria and specifying ambient standards are essentially combined in a single step in all jurisdictions. Ontario's Blue Book comes closest to recognizing this judgment factor. It is noted that current understanding of chemical dynamics and effects on aquatic life are limited to a few species and to contaminant levels that are lethal in short-term tests. "Application factors", i.e. ratios of the maximum concentration having no negative effect on test organisms to the 96-hour LC-50 concentration, are therefore developed. This approach, it is admitted, is "not ideal, but is a practical method of making an estimate

of a safe concentration from limited toxicity data" (3a). The Blue Book also notes that synergistic effects may not be taken into account by ambient standards. Ontario, like all other jurisdictions, specifies a mixing zone concept to provide for effluent dilution.

Another example of judgment application is Ontario modification of ambient dissolved solids standards for particular waters in the Elliott Lake Area. The Environmental Assessment Board concluded, following a hearing, that the less than 1/3 increase over background standard was scientifically uncertain and overstringent in its application to mining operations in the area. It recommended that a 500 mg/l total dissolved solids standard be applied in the Elliott Lake Area, and this was accepted by the Minister (10).

Generally, as in the case of water, ambient air standards are established by inhouse technical processes that essentially combine objective identification, criteria development and ambient standard setting. The Federal ambient air quality objectives that were developed with provincial participation are often referred to by provincial officials. For example, Alberta emphasizes that its ambient air standards are generally related to the highest Federal objective level - maximum desirable.

The Ontario and Federal processes are best documented and appear to be the most elaborate. In Ontario there is an Environmental Air Standards Setting Committee. The Committee is concerned with documentation and evaluation with a view to developing recommendations for ambient air quality "criteria" (i.e. objectives or standards) as well as emission standards or guidelines. It is an interdisciplinary Committee with two technical subcommittees. The subcommittees develop source and ambient air testing procedures for each air contaminant considered.

The Committee's procedure is as follows (5):

1. A written request for a standard accompanied by an outline of surrounding circumstances is directed to the Committee chairman.
2. The request is forwarded to Committee members. Members initiate investigations in their respective areas of expertise. Reports indicating suggested criteria including full rationale, in relation to human health,

vegetation, animals, and property, are submitted to the Chairman.

3. Copies of reports are circulated. The Chairman proposes a tentative 24 hour ambient air objective and corresponding point of impingement standard for discussion with regional organizations and others.
4. When the Committee has agreed upon an ambient air objective, an emission standard is chosen that if met by all sources will maintain the ambient objective. The two subcommittees then develop methods of source and ambient air analysis.
5. The proposed ambient objective and emission standard are forwarded to the responsible assistant deputy minister for review and distribution to relevant branches as "tentative" values. They are also vetted by legal staff. Cabinet directive requires that a socio-economic impact statement be prepared and reviewed at this stage. This appears to be an inhouse process. Following Cabinet approval, the values are incorporated in the Environmental Protection Act regulations.
6. Where considerable time is required for development of necessary data concerning an air contaminant, but urgency is involved, the Committee Chairman will propose a provisional guideline (including a 24 hour ambient objective) based on available data. This guideline may remain in use until adequate information is available.

The Committee has classified ambient air quality "criteria" (standards/objectives) into the following categories:

- I - Ambient Air Quality Criteria
- II - Tentative Criteria
- III - Guideline Criteria
- IV - Provisional Guideline Criteria

As information improves, an ambient value for a particular contaminant may be "upgraded" from provisional to guideline, to tentative, and eventually to full ambient air quality "criteria" (standard/objective) status.

Federal ambient objectives are developed by a subcommittee of the Federal-Provincial Committee on Air Pollution(11). The Committee is chaired by the Federal Air Pollution Control Director General and includes senior provincial officials. There are two subcommittees, one to consider maximum desirable and maximum acceptable national air quality objectives, and one to consider maximum tolerable objectives. The Subcommittee on National Air Quality consists of experts in various relevant

fields. The subcommittee operations begin with a literature search to identify criteria that have been developed elsewhere and to determine the magnitude of the problem with particular pollutants in particular areas of Canada. Next, working papers on the contaminant in question are prepared by the various specialists on the subcommittee. The subcommittee then meets under a provincial chairman to consider this information. Discussion is held and consensus reached as to maximum desirable, maximum acceptable and maximum tolerable levels. Values for the first two levels are essentially scientific matters. Maximum acceptable corresponds in concept to U.S. Federal Secondary Air Quality Standards and to Ontario ambient air quality criteria. Maximum desirable provides a long term air quality goal and an anti-degradation policy for unpolluted areas.

However the maximum tolerable value may be described as a "political level". Here economic issues and questions related to best available technology are particularly relevant.

Subcommittee recommendations, and particularly the maximum tolerable level, are then considered by the full Committee. When decisions are reached these values are reported back to the Environmental Protection Service of Environment Canada and eventually published as national air quality objectives.

One major difference between ambient air and water standards is that ambient air values are more likely to be promulgated as regulations. This is done for air values in Alberta, Saskatchewan and Ontario. The Federal objectives are also regulations, made under specific Clean Air Act authority. Breach of Saskatchewan's ambient air quality standards is an offence and is therefore directly enforceable. The other ambient air standards are not directly enforceable and in this sense differ little from non-regulation guidelines or objectives.

SPECIFICATION OF EMISSION STANDARDS

Generally, water effluent standards are intended to limit emissions so as to maintain receiving water conditions within the ambient standards specified for a particular jurisdiction. British Columbia includes water effluent standards in its industry-by-industry "objectives". Alberta publishes water effluent "guidelines" for major industries in the province. The Federal government has promulgated effluent regulations as well as monitoring and testing guidelines on an industry basis under the Fisheries Act. Ontario's Objectives for the

Control of Industrial Waste Discharges(12) are general and apply to all industries. Only the Federal standards are directly enforceable.

The Alberta and Federal effluent standards were developed using a government-industry task force approach(13). Alberta task forces first surveyed plants to identify waste loadings, then determined reasonable performance levels for each particular type of plant. Where relevant, previous experience with Federal Fisheries Act regulation development was drawn upon. Alternative disposal techniques (e.g., surface water, sewage treatment plant, evaporation, deep well disposal) were then considered to establish minimum baseline standards (14) and best practicable technology was agreed upon for the disposal method chosen. Generally, task forces use the Alberta ambient standards as outside limits. However, whether or not discharges that may produce conditions in excess of ambient objectives are a concern depends on the assimilative capacity of the water in question. The ultimate product of each Task Force work is published effluent guidelines for particular industries.

Federal-industry task forces have included representatives of industry and provincial environment officials. This process has been well documented(15)(16).

British Columbia's inquiry approach is the only example of wide public involvement in effluent standard setting. Technical meetings with industry representatives are also a feature of the British Columbia process.

The Ontario Blue Book states that site-specific effluent standards will be set based on the assimilative capacity of a water body and on the provincial ambient objectives(3b). Federal effluent standards are taken into account under the Canada-Ontario Accord that implements the Canada-U.S. Great Lakes Basin Agreement. Ontario has agreed to establish and enforce requirements at least as stringent as the Federal baseline effluent requirements under the Fisheries Act regulations. While the generally applicable Industrial Waste Objectives were developed with provincial ambient objectives and Federal standards in view, the Blue Book stipulates that for a particular plant site, specific assessment may require a more stringent standard. Thus the more stringent of the assessment requirements, the Federal standards, or the provincial industrial effluent objectives, will be applied in all cases. Nonpoint sources will also be considered in the establishment of effluent standards for particular discharges. For municipal wastes, Ontario policy, though

not formally published, is to require secondary treatment as a minimum. Basically this means 15 ppm BOD and 15 ppm suspended solids as specified in the Industrial Waste Objectives.

Saskatchewan, with relatively little major industry, has no water effluent standards. Licensing is on a case-by-case basis with the ambient objectives as general guidelines. The objectives document does specify that maintenance of minimum ambient conditions requires the equivalent of primary treatment of sewage.

Alberta air emission standards are developed following industry input, primarily on technology issues, through task force processes(4d). Emission standards are related to provincial ambient air quality objectives through the use of dispersion models(4b). Best practicable control technology (BPT) is considered and determined by Alberta government-industry task forces or through Federal-provincial-industry task forces. The latter are charged with determining Federal ambient air quality objectives. However, Alberta normally adopts the control technology recommendations of these joint task forces(4c). Where hazardous air contaminants such as vinyl chloride are in issue, best available technology (BAT) may be considered and adopted. The result of this process is published emission guidelines for particular industries.

The procedure of Ontario's Environmental Air Standards Setting Committee was described in relation to ambient standards. For emissions, half-hour point-of-impingement standards are developed for each contaminant, along with 24-hour ambient values. The point-of-impingement values recommended by the Committee, are, when reviewed by the responsible assistant deputy minister, and approved by Cabinet, incorporated in Ontario Regulation 15, 1971. If information is incomplete, a provisional guideline may be established, then upgraded as information improves, to a guideline, a tentative standard and finally, a standard to be incorporated in the Regulation(17).

Generally, standards are directly related to ambient values(6c). Factors such as sampling time differentials, health effect considerations, practical emission control considerations, including cost, and background concentrations are taken into account in moving from ambient to source emission values(6c)(18).

Martin and Kupa(6d) note the judgment factor involved in derivation of Ontario emission standards. They identify

certain basic assumptions in the process, including use of codified plume rise and diffusion equations, and an average background concentration for common contaminants. If these basic assumptions do not hold in a given situation then more stringent local emission standards must be applied to ensure that ambient standards are met. An example is the regulation establishing a special local SO₂ standard for the Sarnia area.

By their nature the Ontario point-of-impingement standards (half-hour concentration at receptors located according to prescribed formulae) take into consideration local micrometeorology, topography and land use. They are set so that in general, if all sources abide by them, the ambient air quality objectives will be satisfied.

Saskatchewan has no air emission standards. However, work is in progress to develop standards for potash facilities and thermal power plants. A government-industry task force has worked on potash standards. Regulations have been drafted and subjected to legislative review, and are now before Cabinet. In the case of thermal power plants, attention is centered on review and analysis of the recently issued Federal guideline(19).

PERMIT TERMS AND CONDITIONS

Permits or licences for plants in the case study categories were reviewed for British Columbia, Alberta, Saskatchewan, and Ontario. Generally, provincial effluent "standards" (objectives or guidelines) are followed in licensing discharges. These values are usually considered to be maximum discharge limits.

The water approvals system in Ontario has been described in relation to emission standards. Compliance with province-wide effluent objectives is the basic requirement for obtaining a certificate of approval. But where site specific assessment suggests that more stringent effluent standards may be required to meet provincial ambient standards or Federal requirements, the more stringent requirements are imposed(3b). For sewage treatment plants a basic 15/15 ppm BOD/suspended solids requirement is the starting point. Discussions then take place between regional officials and municipal engineers or consultants to finalize facilities and design requirements.

Ontario Certificates of Approval are formal certificates that contain relatively little detail. The nature of the plant or treatment equipment that is the subject of approval is spelled out in some technical detail. However, certificates reviewed contained few conditions. Conditions included monitoring requirements to be determined or approved by Ontario Environment, and requirements to apply for approval of additional treatment facilities in the event problems are disclosed by monitoring. To understand abatement requirements in a particular case it is necessary to read the Certificate of Approval along with the detailed information contained in the application form and supporting documents.

Where conditions are included, a notice form is attached to the Certificate of Approval. This form sets out short reasons for imposition of the condition and advises that by written notice, within 15 days of receipt of the notice, a hearing by the Environmental Appeal Board may be required(20). Reasons for monitoring requirements included reference to meeting Ontario ambient objectives. Reasons for conditions designed to minimize foam generation by a Kraft pulp and paper mill referred to terms of the statutory definition of "contaminant", i.e., discomfort to persons, loss of enjoyment of normal use of property and impairment of water quality in the particular river.

Apparently, recent sewage treatment plant certificates have for the first time included numerical effluent standards for the main contaminants in 12-month average terms. These are based on statistical determination of what particular secondary treatment processes are likely to produce as effluent.

Alberta Clean Water Act licences are conditioned with reference to relevant effluent guidelines for the particular industry. Guideline requirements are considered to be minimums. Numerical contaminant values are maximum discharge limits. More stringent requirements may be imposed. For example, in the case of gas treatment plants, requirements were noted for more stringent basic BOD and suspended solids concentration values than are normally specified in the Gas Processing Plants Waste Water Management Standards(21).

Licences in Alberta contain detailed conditions. More complex licences are drafted in a relatively standard form, beginning with a definition section, and containing sections outlining general requirements including treatment and discharge specifications; numerical waste water effluent standards; monitoring requirements; reporting specifications; and licence term. Five-year licence terms are specified. Licence effluent

standards and monitoring requirements often specifically incorporate the relevant industry effluent guideline requirements by reference.

British Columbia permits are comprehensive, covering air, water and land discharges from a particular plant. Permit effluent requirements are based on the effluent "objectives" for the particular industry. Detailed terms and conditions are included in the permit and additional terms and conditions are usually included in the letter of transmittal from the Department to the permittee. These cover such matters as equipment, design, monitoring and reporting.

Alberta Clean Air Act licences are generally similar in form to the water licences already described. The key section contains operating and emission requirements. A standard clause provides that the plant shall be operated so that release of contaminants does not result in concentrations in excess of those specified in Part I of The Clean Air (Maximum Levels) Regulations. The regulation values are ambient standards that include short-term time averages for major contaminants such as nitrogen dioxide (one-hour concentration) requirements of the Alberta Source Sampling Code, and the monitoring and reporting requirements of the Air Monitoring Directives(22) that have been published for major industries. As in the case of water requirements, air abatement technology and emission standards specified in licences are developed through a process of staff discussions with particular applicants.

Ontario air certificates, like water certificates, contain few specific conditions. These included specific monitoring conditions. However, not all certificates reviewed contained monitoring and reporting requirements, and those included were in less detail than Alberta requirements. One condition shows how Ontario "guideline"(17) standards are used. The condition stated that if at some future date a legal standard for vinyl chloride is enacted that is more stringent than the existing guideline, the applicant must take steps to comply with that standard. Formal reasons explained that while vinyl chloride is a carcinogenic compound there is insufficient information to establish a standard. Consequently, the reasons stated that a "guideline" of 560 $\mu\text{g}/\text{m}^3$ half-hour point-of-impingement is presently used in approving applications.

Generally, Ontario applicants must comply with the half-hour average point-of-impingement standards specified by Regulation 15. As the above example shows, provisional guideline,

guideline, and tentative standard values are also used to assess applications, pending information necessary to develop legal standards for incorporation in Regulation 15.

In the case of operating plants that did not meet Ontario emission standards when standards were first prescribed, program approvals and latterly control orders that require certain abatement equipment installation over a specified time period are used. For certain industries, notably pulp and paper, control orders are used as a form of licensing. All older mills are under control orders that specify abatement equipment and facilities development within specified time frames. When basic treatment objectives are achieved, new control orders are issued to deal, for example, with toxics. Control orders are used in this way because they carry heavier and more formal compliance expectations, and because they are more flexible than program approvals. Amendment is relatively easy, and prosecution or other enforcement action for breach is not hampered by the prosecution immunity that attaches to program approvals where applicants are substantially in compliance.

Special regulations may also be used in combination with control orders. An example is the regulation covering Inco Ltd's Copper Cliff Smelter Complex(23).

THE ROLE OF THE PUBLIC

There is essentially no public role in ambient or emission standard setting in Alberta, Saskatchewan or Ontario. However, officials in these provinces acknowledged the value of such participation in gathering information and particularly in promoting public confidence in standards. Ontario officials pointed out that public involvement is important where standards are considered for contaminants that are harmful to human health, but for which no threshold effects level has been identified. Here the judgment aspect of standard setting is particularly prominent since risk assessment that may, in effect, involve trading off human lives against industrial benefits may be involved. Clearly in these circumstances environment Ministry technical staff would be more comfortable with a broadly based decision process.

Ontario officials noted that the International Joint Commission (IJC) held hearings on draft objectives proposed under the Great Lakes Basin Agreement. Since a relatively high percentage of Ontario water standards can be traced to IJC sources it was suggested that there has been indirect public input in

relation to Ontario standards. There are indications that these IJC hearings have been used to rationalize the lack of public input in Ontario standard setting. However, the IJC hearings have been described as overly technical and held with insufficient opportunity for members of the public to prepare(24).

Recent public pressure on Ontario Environment, particularly through the media and by the Legislative Opposition concerning standards for toxic substances in drinking water and hazardous waste disposal issues, has created a climate favorable to public participation. The idea of a representative Environmental Standards Advisory Council, analogous to the Advisory Council on Occupational Health and Safety(24a) established under the Occupational Health and Safety Act, 1978, is being discussed by senior management in the Ministry.

At the permitting level, Ontario does require hearings for hazardous waste disposal and for sewage plant certificate applications involving the equivalent waste of over 1500 persons(20a). There is also a discretion in the Director to hold a public hearing on other applications.

As a matter of policy Ontario Environment also makes provision for public involvement in review of company reports on abatement options in program approval and control order processes(25). Local residents are informed and given an opportunity to comment where control order amendments are proposed.

There has been no public involvement in the development of Federal air and water standards. However, the Federal Department of the Environment's new Public Consultation Policy(26) provides for notice and an opportunity to comment in writing on proposed regulations, as well as annual briefings and policy discussion opportunities for public and private interest groups, professional associations, and concerned individuals.

In Alberta, public hearings in which permit standards may be in issue are held by the Energy Resources Conservation Board on applications for approval of energy related projects. And Saskatchewan has had one public inquiry on a municipal sewage plant application. Officials indicated that public participation in standard setting for major projects is likely to occur through discretionary inquiries under the Environmental Assessment Act.

British Columbia's standard setting process is unique in that its industry-by-industry

ambient and emission "objectives" were developed after an extensive consultation process involving both industry and the public. The procedure used has evolved to some extent since the first objectives were issued, but basic to the process in all cases was the appointment of an advisory panel. Its members were selected for their technical expertise, and included experts from outside government as well as government employees. An economist was included on each panel to assure that the economic costs and benefits of proposed guidelines were considered. Hearings were held, chaired by the Director of Pollution Control, who was assisted by legal counsel. Following the hearings, and after deliberation and analysis, each panel wrote a report recommending the objectives to be adopted. These reports were then forwarded to the Pollution Control Board for formal adoption.

The hearings were fairly formal and technically oriented, and have been criticised on that basis. Participants presented briefs and oral testimony and were allowed to cross-examine the experts put forward by other participants. Questioning by panel members was also encouraged and was, at times, vigorous. The panels were not limited to information brought forward during the hearing. Information could be requested from the staff of the Pollution Control Branch or could be brought in by the panelists themselves. Since panels included experts from each relevant discipline it must be assumed that the panels were aware of all of the latest developments with respect to environmental standards. However, there was no formal mechanism for tabling this information or obtaining comment with respect to it.

After reviewing British Columbia's hearing procedure, one commentator has concluded:

"[P]rocedures for participation in setting objectives have heavily favoured the technically informed, when the question is really one that depends at least as much on public value preferences as on technical considerations. To date, submissions by those outside government expressing "environmental values" have probably not influenced decision-making to any extent." (27)

The criticism seems fair, but British Columbia should be commended for developing an organized system of public participation in the standard-setting process. It should be remembered that these hearings were held at a time when there were few if any precedents that could have been followed.

Since that time the Province has developed other, more informal means of involving the public. The most recent reviews, for example, have included informal meetings at which public reactions were sought. These would presumably answer the criticism that the procedures were too technical and inhibited input by the general public.

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CHAPTER 5

COMPARISON OF AMBIENT STANDARDS

This chapter compares standards for ambient air and water quality in the study provinces and for the Canadian and U.S. Federal governments. This is preceded by a discussion of the major pollutants, their sources, and major effects on the environment. The term "standard" is used as defined in Chapter 2, i.e., to include both legally enforceable standards and other formally published values.

AIR

Major Pollutants

The major pollutants identified in the study are the particulates and the gaseous pollutants, carbon monoxide, hydrogen sulphide, sulphur dioxide, oxides of nitrogen, and oxidants (ozone).

Particulates. The term particulates refers to many different finely divided nongaseous substances suspended in the air. They arise in industrial operations - the chief source - and also in combustion of fuels for power generation and transportation, especially in automobiles. Transportation emissions, while not so voluminous as those from several other sources, are of special concern because they contain carcinogens and lead. Adverse effects on health may be caused by lodging of particles in lungs. Particulates can also cause soiling of materials, and can interfere with visibility.

Dustfall. Closely allied to particulates is dustfall, which is made up of particles that do not remain suspended. These particulates can cause considerable maintenance problems, such as abrasion, adherence to wet paint, and necessity for exterior cleaning of buildings.

Carbon monoxide. Most of the carbon monoxide generated by human activity comes from transportation, most notably, the automobile. Its significance lies in its toxic effects, which may be manifested by impairment of health or performance. The problem is particularly serious in areas of high traffic density or restricted circulation of air contaminated by motor exhausts.

Hydrogen sulphide. Although a great deal of hydrogen sulphide is emitted into the atmosphere by natural phenomena, it is a toxic gas and may have special local significance because even very small concentrations produce a pronounced "rotten egg" odor.

Sulphur dioxide. Sulphur dioxide emissions into the atmosphere result almost entirely from human activity. Most come from industry and the combustion of sulphur-containing fossil fuels for power generation. They can cause considerable damage to vegetation at high concentrations and were, in fact, of great concern in the investigations of damage to plant life near the smelter at Trail, B.C. in the 1930s. Sulphur dioxide is now of greatest concern in connection with the acid rain problem.

Nitrogen oxides. Transportation activity byproducts, particularly motor vehicle exhaust, are the largest contributors to the oxides of nitrogen problem. Oxides of nitrogen combine with hydrocarbons to form photochemical smog, which is an aesthetic nuisance, a source of eye irritation, a danger to plant life, and a cause of corrosion.

Oxidants (ozone). These substances, in concentrations found in heavily polluted air, can cause respiratory irritation and damage to plant life. Oxidants result from the chemical reaction of nitrogen dioxide and hydrocarbons in the presence of sunlight. "Total oxidants" encompasses all atmospheric oxidants measurable by oxidation of iodide ions, including organic peroxy-nitrogen compounds and nitrogen dioxide as well as ozone. Under conditions of high photochemical activity, ozone represents 90% or more of the total oxidants. High natural background levels of oxidants (ozone) can occur, even in the absence of activities generating the usual precursor pollutants, especially in the areas with abundant sunlight and vegetation.

Comparison of Standards

Table 5.1 shows the standards for ambient air quality in the study jurisdictions.*

The similarities and differences in the structures of these

* Reference numbers in the Table refer to the list entitled "Standards Sources", following Chapter 6.

TABLE 5.1 AMBIENT AIR STANDARDS

STANDARD FOR GIVEN JURISDICTION							
Parameter	Time Period	Alberta 1.1 (25°C)	British Columbia 2.1-2.4 (20°C)	Ontario 3.1 (10°C)	Saskatchewan 4.1	Canada-Federal 5.1-5.3 (25°C)	U.S. Federal 6.16 (25°C)
Carbon monoxide	8 hrs	6 mg/m ³	A-5.5 mg/m ³ B-11.0 mg/m ³ C-14.3 mg/m ³ 2.2	15.7 mg/m ³	6 mg/m ³	0-6 mg/m ³ desirable 5.1 6-15 mg/m ³ acceptable 5.1 15-20 mg/m ³ tolerable 5.3	10 mg/m ³
	1 hr	15 mg/m ³	A-14.3 mg/m ³ B-28.0 mg/m ³ C-35.0 mg/m ³ 2.2	36.2 mg/m ³	15 mg/m ³	0-15 mg/m ³ desirable 5.1 15-35 mg/m ³ acceptable 5.1	40 mg/m ³
Dustfall	30 days/ 1 month	Residential areas: 53 mg/100 cm ² /30 days= 15 tons/mi ² /mo. (with allowance for normal background)	Residential areas: A - 15 tons/ mi ² /mo. 2.1-2.3 B - 15 tons/ mi ² /mo 2.2,2.3 20 tons/mi ² /mo 2.1 C - 20 tons/ mi ² /mo 2.1,2.2 15-25 tons/mi ² 2.4	All areas: 20 tons/mi ² /mo	-	-	-

Continued...

TABLE 5.1 AMBIENT AIR STANDARDS (continued)

Parameter	Time Period	STANDARD FOR GIVEN JURISDICTION					
		Alberta 1.1 (25°C)	2.1-2.4 British Columbia (20°C)	3.1 Ontario (10°C)	4.1 Saskatchewan	5.1-5.3 Canada-Federal (25°C)	6.16 U.S. Federal (25°C)
Dustfall	30 days/ 1 month (cont.)	Other areas: 158 mg/100cm ² /30 days= 45 tons/mi ² /mo (with allowance for normal background)	Other areas: A - 25 tons/ mi ² /mo 2.1-2.3 B - 25 tons/ mi ² /mo 2.2,2.3 30 tons/ mi ² /mo 2.1 C - 35 tons/ mi ² /mo 2.1,2.2 15-25 tons/ mi ² /mo 2.4	-	-	-	-
Hydrogen sulphide	1 year	-	-	13 tons/mi ² /mo avg	-	-	-
	24 hrs.	4ug/m ³	A-4ug/m ³ 2.2 B-7.5ug/m ³ 2.1 6ug/m ³ 2.2 C-7.5ug/m ³ 2.1 8ug/m ³ 2.2	-	-	-	-
	1 hr.	14ug/m ³	A-7.5ug/m ³ 2.1 14ug/m ³ 2.2 B-45ug/m ³ 2.1 28ug/m ³ 2.2 C-45ug/m ³ 2.1 42ug/m ³ 2.2	30ug/m ³	-	-	-

Continued...

TABLE 5.1 AMBIENT AIR STANDARDS (continued)

Parameter	Time Period	STANDARD FOR GIVEN JURISDICTION					
		1.1 Alberta (25°C)	2.1-2.4 British Columbia (20°C)	3.1 Ontario (10°C)	4.1 Saskatchewan	5.1-5.3 Canada Federal (25°C)	6.16 U.S. Federal (25°C)
Nitrogen dioxide	1 year	60 ug/m ³ max.	-	-	100ug/m ³	0-60ug/m ³ desirable 0-100ug/m ³ acceptable	100ug/m ³
	24 hrs	200ug/m ³	-	200ug/m ³	200ug/m ³	0-200ug/m ³ acceptable 200-300ug/m ³ tolerable	-
	1 hr	400ug/m ³	-	400ug/m ³	400ug/m ³	0-400ug/m ³ acceptable 400-1,000ug/m ³ tolerable	-
Oxidants (Ozone)	1 year	-	-	-	-	0-30ug/m ³ acceptable 0-30ug/m ³ desirable	-
	24 hrs	50ug/m ³ as equiv. O ₃	-	-	30ug/m ³ (O ₃)	0-30ug/m ³ acceptable 30-50 ug/m ³ desirable	-
	1 hr	160ug/m ³ as equiv. O ₃	-	total oxidants: 0.1 ppm-200 ug/m ³ m ³ as O ₃ O ₃ :0.08 ppm = 165ug/m ³	100ug/m ³ (O ₃)	0-100ug/m ³ desirable 100-160ug/m ³ acceptable 160-300ug/m ³ tolerable	235ug/m ³ (25°C)

Continued....

TABLE 5.1 AMBIENT AIR STANDARDS (continued)

Parameter	Time Period	STANDARD FOR GIVEN JURISDICTION					
		Alberta 1.1 (25°C)	British Columbia 2.1-2.4 (20°C)	Ontario 3.1 (10°C)	Saskatchewan 4.1	Canada-Federal 5.1-5.3 (25°C)	U.S. Federal 6.16 (25°C)
Sulphur dioxide	1 year	30ug/m ³	A-25ug/m ³ ^{2.1-2.3} B-50ug/m ³ ^{2.1-2.3} C-80ug/m ³ ^{2.1-2.2} 25-75ug/m ³ ^{2.4}	55ug/m ³	30ug/m ³	0-30ug/m ³ ^{5.1} desirable 30-60ug/m ³ ^{5.1} acceptable	80ug/m ³ primary std.
	24 hrs	150ug/m ³	A-160ug/m ³ ^{2.1-2.3} B-260ug/m ³ ^{2.1-2.3} C-360ug/m ³ ^{2.1,2.2} 160-260ug/m ³ ^{2.4}	275ug/m ³	150ug/m ³	0-150ug/m ³ ^{5.1} desirable 150-300ug/m ³ ^{5.1} acceptable 300-800ug/m ³ ^{5.3} tolerable	355ug/m ³ primary std.
	3 hrs	-	375-665ug/m ³ ^{2.4}	-	-	-	1,300ug/m ³ secondary std.
	1 hr	450ug/m ³	A-450ug/m ³ ^{2.1-2.3} B-900ug/m ³ ^{2.1-2.3} C-1300ug/m ³ ^{2.1} 900ug/m ³ ^{2.2} 450-900ug/m ³ ^{2.4}	690ug/m ³	450ug/m ³	0-450ug/m ³ ^{5.1} desirable 450-900ug/m ³ ^{5.1} acceptable	-

Continued...

TABLE 5.1 AMBIENT AIR STANDARDS (continued)

Parameter	Time Period	STANDARD FOR GIVEN JURISDICTION					
		Alberta 1.1 (25°C)	British Columbia 2.1-2.4 (20°C)	Ontario 3.1 (10°C)	Saskatchewan 4.1	Canada-Federal 5.1-5.3 (25°C)	U.S. Federal 6.16 (25°C)
Suspended particulates	1 year	60ug/m ³	A-60ug/m ³ B-70ug/m ³ C-75ug/m ³ 60-70ug/m ³ 2.1,2.2 2.1,2.2 2.1,2.2 2.3,2.4	60ug/m ³	70ug/m ³	0-60ug/m ³ desirable 60-70ug/m ³ acceptable 5.1	75ug/m ³ primary std. 60ug/m ³ secondary std.
	24 hrs.	100ug/m ³	A-150ug/m ³ B-200ug/m ³ C-260ug/m ³ 150-200ug/m ³ 2.1,2.2 2.1,2.2 2.1,2.2 2.3,2.4	120ug/m ³	120ug/m ³	0-120ug/m ³ acceptable 120-400ug/m ³ tolerable 5.1 5.3	260ug/m ³ primary std. 150ug/m ³ secondary std.

NOTE: 1. Reference temperature is given in heading for each jurisdiction.

2. Values for 24 hours, 3 hours, and 1 hour are averages over the given time period; values for 1 year are arithmetic means, except in the case of suspended particulates, which is a geometric mean.

standards require some comment. All the standards have been constructed so as to make different requirements applicable to different time periods. In general, the quality requirements for one year are higher than those for 24 hours (that is, the allowable quantities of pollutant are lower), which in turn are higher than those for one hour, etc. This obviously is necessary to take into account fluctuations in air quality caused by wide changes in atmospheric conditions. For example, a community could undergo a brief period of high atmospheric contamination caused by trapping of pollutants in an inversion condition without affecting substantially its compliance with the yearly average standard.

Several of the jurisdictions have various levels of ambient standards. British Columbia has A, B, and C levels, the significance of which is explained as follows: "The ambient air-quality guidelines are not intended as control objectives but are considered minimum desirable levels of air quality. If the ambient air quality is not maintained as a result of the emissions objectives, the latter may be revised to meet the ambient air-quality guidelines". In the Canadian Federal objectives, the maximum desirable level represents a long-term goal, and provides a basis for an antidegradation policy for unpolluted areas and for the continuing development of control technology. The maximum acceptable level is defined as that providing "protection against effects on soil, water, vegetation, materials, animals, visibility, personal comfort, and well-being". When this level is exceeded, action by a regulatory agency is indicated. The maximum tolerable level represents a level beyond which, because of a diminishing margin of safety, action is required to protect the health of the general population.

The U.S. defines its secondary ambient air quality standards as levels necessary to "protect the public welfare from any known or anticipated adverse effects of a pollutant", and its primary standards as "necessary, with an adequate margin of safety, to protect the public health." Thus, the Canadian maximum acceptable level and the U.S. secondary standard are substantially identical in philosophy.

Reference temperature has an effect on the concentration levels given for pollutants, but because the differences are not large between the reference temperatures of the various jurisdictions, this effect will not be considered for the purposes of the semiquantitative comparisons of this study.

All jurisdictions studied have standards covering most of the parameters of concern. Several parameters are covered

by only a few jurisdictions. In spite of the role of hydrocarbon emissions in the formation of photochemical smog, the standard for this parameter was found only for the U.S., where a maximum 3-hr concentration of 160 mg/m^3 (0.24 ppm) is prescribed.

The single most striking feature of the comparison of standards is the influence of the Canadian Federal standards on those set by the provinces. The table shows that the Federal "desirable" level is identical with the following: Particulates: annual average in Alberta, B.C.(A), and Ontario; Carbon monoxide: 8-hour and 1-hour values in Alberta, B.C.(A) (approximately), and Saskatchewan; Oxides of nitrogen: annual average in Alberta; Oxidants: 24-hour and 1-hour values in Saskatchewan; Sulphur dioxide: annual average, 24-hour, and 1-hour values in Alberta, B.C.(A) (approximately), and Saskatchewan. In addition, the Canadian Federal "acceptable" level is substantially identical with the following: Particulates: annual average in B.C.(B), and Saskatchewan; 24-hour value in Saskatchewan and Ontario; Oxides of nitrogen: annual average in Saskatchewan, 24-hour and 1-hour value in Alberta, Ontario, and Saskatchewan; Oxidants: 24-hour and 1-hour values in Alberta; sulphur dioxide: 1-hour value in B.C. (B).

The Canadian Federal standards appear to compare favorably with the U.S. standards. For suspended particulates, the Canadian and U.S. standards are substantially the same. For carbon monoxide, the U.S. standard is in the Canadian "acceptable" range for the 8-hour period, whereas the U.S.'s 1-hour standard is more lax. The U.S. nitrogen dioxide standard is in the Canadian "acceptable" range, whereas the standards of oxidants (1 hour) and sulphur dioxide (24 hours) for the U.S. correspond more closely to the Canadian "tolerable" range.

Several parameters are mentioned by only a few jurisdictions. Alberta, British Columbia, and Ontario have standards for dustfall that all appear to be in the same range. Both Alberta and British Columbia distinguish between standards to be met in residential areas and the less strict standards to be met in industrial and other areas.

Standards for hydrogen sulphide are also given by these three provinces. Alberta's appears quite stringent, being more restrictive than any except that proposed by British Columbia for the oil and gas industry (A level) and being equivalent to British Columbia's A level for other industries.

WATER

Water Quality Parameters

The parameters relevant to ambient water quality may be classified as physical, chemical (metals, inorganic nonmetals, and organics), radioactive, and microbiological. Physical parameters tend to have a significant impact on aesthetic acceptability of a water body. Examples are turbidity, odour, and colour. Other physical parameters, such as temperature, can have an impact on aquatic life.

Among the chemical parameters, metals, especially the heavy metals, are an important concern. The heavy metals can be toxic to aquatic life even at extremely small concentrations, and can accumulate in the food chain. Thus, they can be potentially toxic to humans ingesting contaminated aquatic organisms. Certain inorganic nonmetals such as cyanide also are toxic. Others, such as fluoride, may be desirable in small concentrations but are suspected of posing dangers to health at larger concentrations. Nitrogen and phosphorus, under certain conditions, can cause over-fertilization of a body of water and nuisance blooms of algae or excessive growth of other aquatic plants. A discussion of the significance and interconvertibility of the various nitrogen forms may be found in "Standard Methods for the Examination of Water and Wastewater". One constituent, dissolved oxygen, is indispensable for aquatic life and certain minimum, rather than maximum, concentrations are prescribed. Certain organic substances may be objectionable on the grounds of aesthetic impairment (oil and grease, surfactant foam) and others on the grounds of toxicity (pesticides, PCBs).

Limits are set for radioactivity to limit the exposure of the public through the drinking water supply.

Coliform organisms are limited not because they are harmful in themselves, but because they are indicators of recent fecal contamination, which could be accompanied by pathogenic microorganisms. The latter are difficult to isolate, and so total coliforms, and more recently fecal coliforms, have been used as "indicator organisms".

Comparison of Standards

Table 5.2 shows the ambient water standards and other formally published values for the study jurisdictions.*

Most of the standards identified are explicitly aimed at the protection of specific uses of the ambient water. Some jurisdictions have separate limits for such uses as domestic supply, aquatic life, recreation, livestock watering, and irrigation. The standards developed jointly by Alberta and Saskatchewan, on the other hand, are general, although they are aimed at protection of all water uses. British Columbia's recommendations vary, depending on the set of standards used (grouped by industry). This is not a very rational approach because the user of the ambient water is essentially "blind" to the source of contaminants, caring only about their effect on the potential use. However, these values are not to be understood as being applicable for control purposes in B.C. The approach in that province is essentially discharge-quality-oriented, and the ambient levels are looked upon more as means for gauging the effectiveness of the effluent controls. British Columbia does, however, have separate standards for drinking water.

Most of the limitations for the physical variables are given in terms of maximum change from the "natural", "background", or "ambient" condition. This condition must, of course, be defined by some body of data. This applies, for example, to temperature, turbidity, and suspended solids. For variables where absolute figures are given, stringency varies. Whereas the values for colour in the Canadian jurisdictions are all similar, that given by the U.S. is considerably less stringent. On the other hand, the Canadian Federal government recommendation for threshold odour number is not so restrictive as those of Alberta, Saskatchewan, or British Columbia.

The form of the ambient standards for metals varies among the jurisdictions. British Columbia specifies "no measurable change" for all heavy metals. The U.S. puts many of its limits on the basis of 0.01 times the 50% lethal concentration. These limits are therefore not directly comparable to those of other jurisdictions. For domestic water supply, the uniformity of the standards is very striking. The values are identical for all jurisdictions studied for barium, cadmium,

* Reference numbers in Table refer to the list entitled "Standards Sources", following Chapter 6.

TABLE 5.2 AMBIENT WATER STANDARDS

PARAMETER	STANDARD IN GIVEN JURISDICTION				
	ALBERTA-SASKATCHEWAN ^{1,2,4,2*}	BRITISH COLUMBIA ^{2,1-2,6}	ONTARIO ^{3,2**}	CANADA-FEDERAL ^{5,4,5,5[#]}	U.S. FEDERAL ^{6,1}
PHYSICAL:					
Colour [†]	-	50 Pt-Co units (shellfish propagation) ^{2,6}	-	-	Not to reduce depth of photosynthetic compensation point >10%
	15 Pt-Co units (Sask.)	15 Pt-Co units ^{2,6}	-	15 Pt-Co units ^{5,5}	75 Pt-Co units
	-	15 Pt-Co units ^{2,6}	-	15 Pt-Co units objective, 100 max. ^{5,5}	-
	Natural + 30 units	Negligible change from natural ^{2,2,2,3,2,4}	-	-	-
Odour (TON = threshold odour number)	TON < 3 (Sask.)	TON < 2.6	-	TON: no sample > 8 2/3 of monthly samples < 4 TON < 16 ^{5,5}	-
	-	-	-	-	-
	TON < 8	-	-	-	-

* Values for "General" use pertain to both Alberta and Saskatchewan. Saskatchewan has, in addition, special standard for "Domestic supply".

** Ontario standards for drinking water and irrigation apply to groundwater as well as surface water, as do Ontario standards for aquatic life where groundwater is likely to become a major component of stream flow.

† Pt-Co units = platinum-cobalt units. A colour reading of 1 Pt-Co unit is equivalent to that given by 1 mg Pt per liter, in the form of chloroplatinate ion, in the visual comparison method given in "Standard Methods for the Examination of Water and Wastewater". Unspecified "units" given for Alberta and Saskatchewan are presumed to be equivalent.

Ref. 5.5, in addition to the "acceptable" and/or "maximum permissible" values tabulated here, contained "objectives" for a number of parameters. These are as follows: Odour (for recreation) - inoffensive; barium, cyanide, sulphide as H₂S, 2,4-D, 2,4,5-TP, chlordane, DDT, dieldrin, endrin, heptachlor, lindane, methoxychlor, toxaphene, phenolics, (for domestic supply) - not detectable; (all for domestic supply): iron - < 0.05 mg/L dissolved; magnesium - < 50 mg/L; manganese - < 0.01 mg/L; chloride - < 250 mg/L; fluoride - 1.2 mg/L; nitrogen (ammonia) - 0.01 mg/L as N; nitrogen (nitrate and nitrite) - < 10 mg/L as N; sulphate - < 250 mg/L; carbon-chloroform extract - < 0.05 mg/L; MBAS - < 0.2 mg/L; radioactivity - < 10 pCi/L.

Continued...

TABLE 52 AMBIENT WATER STANDARDS (continued)

PARAMETER	PROTECTED USE	STANDARD IN GIVEN JURISDICTION				
		ALBERTA-SASKATCHEWAN ^{1,2,4,2}	BRITISH COLUMBIA ^{2,1-2,6}	ONTARIO ^{3,2}	CANADA-FEDERAL ^{5,4,5,5}	U.S. FEDERAL ^{6,1}
Solids:						
suspended	General	Background + 10 mg/L	Negligible increase ^{2,3}	-	-	Not to reduce depth of photosynthetic compensation point > 10%
total dissolved	Aquatic life	-	-	Ambient + 1/3 (ambient); no alteration of ionic balance	-	-
	Domestic supply	1500 mg/L (Sask.)	1,000 mg/L ^{2,6}	500 mg/L	< 500 mg/L objective (raw) ^{5,5} 1,000mg/L acceptable (raw) ^{5,5}	250 mg/L for chlorides & sulphates
settleable	General	-	Existing + 100 mg/L ^{2,1}	-	-	-
	General	-	Negligible increase ^{2,1,2,2,2,5} 150°C ^{2,6}	-	-	-
Temperature	Aquatic life	-	< + 20°F increase ^{2,1} No measurable change ^{2,3} Natural + 10°C ^{2,2,2,4}	No environmental impairment Ambient + 10°C at edge of mixing zone	< 0.5°C ± from natural max. and min. ^{5,5}	Time- and site-dependent; see Ref. 6.1,p420
	General	Ambient + 3°C	< 5 for disinfection only, natural + 5 for further treatment ^{2,6}	-	< 5 Jackson units ^{5,5}	-
Turbidity [†]	Domestic supply	5 units (Sask.)	< 25 Jackson units ^{2,6}	-	< 5 Jackson units objective; 50 ^{5,5} max.	-
	Recreation (contact)	-	Natural + 5 APHA units ^{2,1,2,2,2,4}	Secchi disk visible 1.2 m	-	-
	General	Natural + 25 Jackson units	Negligible change ^{2,3}	-	-	See Solids, suspended

† Turbidity, an expression of the light-scattering properties of a suspension, may be measured by several methods specified in "Standard Methods for the Examination of Water and Wastewater". The oldest, the Jackson method mentioned by several jurisdictions, requires cumbersome equipment and can only be used directly for turbidities exceeding 25 units. The instrumental nephelometric method is the other standard option, and may be used on natural waters of low turbidity. The two methods are not equivalent, so the method must be specified when results are reported. The Secchi disc method, not recognized as a standard method, is an in-situ, rather than a laboratory, measurement of the depth at which a submerged object remains visible.

Continued...

TABLE 5.2 AMBIENT WATER STANDARDS (continued)

PARAMETER	PROTECTED USE	STANDARD IN GIVEN JURISDICTION				
		ALBERTA-SASKATCHEWAN ^{1,2,4,2}	BRITISH COLUMBIA ^{2,1-2,6}	ONTARIO ^{3,2}	CANADA-FEDERAL ^{5,4,5,5}	U.S. FEDERAL ^{6,1}
METALS Arsenic	Aquatic life	-	-	0.1 mg/L	0.05 mg/L ^{5,4}	(0.05 mg/L suggested)
	Domestic supply	0.01 mg/L (Sask.)	0.05 mg/L ^{2,6}	<0.01 mg/L desirable; 0.05 max.	0.05 mg/L ^{5,4}	0.05 mg/L
	Livestock	-	-	0.2 mg/L	0.05 mg/L ^{5,4}	-
	Irrigation	-	-	0.10 - 2.0 mg/L	0.1-2.0 mg/L depending on crop and soil ^{5,4}	0.1 mg/L
	Recreation	-	-	-	0.05 mg/L ^{5,4}	-
Barium	General	0.01 mg/L	No measurable change (all heavy metals) ^{2,1,2,5}	-	-	-
	Domestic supply	1.0 mg/L (Sask.)	1.0 mg/L ^{2,6}	1.0 mg/L	1 mg/L ^{5,5}	-
	General	1.0 mg/L	No measurable change (all heavy metals) ^{2,1,2,5}	-	-	1 mg/L
Beryllium	Aquatic life	-	-	0.011 mg/L if hardness <75 mg/L CaCO ₃	-	0.011 mg/L in soft fresh water
	Irrigation	-	-	1.1 mg/L if hardness >75 mg/L CaCO ₃	-	1.1 mg/L in hard fresh water
	Aquatic life	-	-	0.10 mg/L - 0.50 mg/L	-	0.1 - 0.5 mg/L
Cadmium	Domestic supply	0.01 mg/L (Sask.)	0.01 mg/L ^{2,6}	0.0002 mg/L	0.0002 mg/L ^{5,4}	0.0004-0.0012 mg/L depending on species and hardness
	Livestock	-	-	0.01 mg/L	0.01 mg/L ^{5,4}	0.01 mg/L
	Irrigation	-	-	0.05 mg/L	0.02 mg/L ^{5,4}	-
	Recreation	-	-	0.01-0.05 mg/L	0.01 mg/L ^{5,4}	-
	General	0.01 mg/L	No measurable change (all heavy metals) ^{2,1,2,5}	-	0.01 mg/L ^{5,4}	-

TABLE 5.2 AMBIENT WATER STANDARDS (continued)

PARAMETER	STANDARD IN GIVEN JURISDICTION				
	ALBERTA-SASKATCHEWAN ^{1,2,4,2}	BRITISH COLUMBIA ^{2,1-2,6}	ONTARIO ^{3,2}	CANADA-FEDERAL ^{5,4,5,5}	U.S. FEDERAL ^{6,1}
Chromium	Aquatic life	-	0.1 mg/L	0.04 mg/L ^{5,4}	0.1 mg/L
	Domestic supply	0.05 mg/L (Sask.)	0.05 mg/L	0.1 mg/L ^{5,4}	0.05 mg/L
	Livestock	-	1.0 mg/L	1.0 mg/L ^{5,4}	-
	Irrigation	-	0.1 - 1.0 mg/L	0.1 mg/L ^{5,4}	-
	Recreation	-	-	0.1 mg/L ^{5,4}	-
Copper	General	0.05 mg/L	-	-	-
	Aquatic life	-	0.005 mg/L	0.002 mg/L ^{5,4}	0.1 x 96-hr LC ₅₀ [†] for sensitive species
	Domestic supply	1.0 mg/L (Sask.)	<1.0 mg/L desirable	0.5 mg/L ^{5,4}	1.0 mg/L
	Livestock	-	0.5 mg/L	1.0 (sheep & cattle) 5.0 mg/L ^{5,4}	-
Iron	Irrigation	-	0.2 - 5.0 mg/L	0.2 - 5.0 mg/L depending on crop and duration of use ^{5,4}	-
	Recreation	-	-	0.5 mg/L ^{5,4}	-
	General	0.02 mg/L	-	-	-
	Aquatic life	-	0.3 mg/L	-	1.0 mg/L
	Domestic supply	0.3 mg/L (Sask.)	<0.3 mg/L desirable	0.3 mg/L (soluble) ^{5,5}	0.3 mg/L
	Irrigation	-	5-20 mg/L	-	-
	General	0.3 mg/L	-	-	-

[†] LC₅₀: The concentration of a toxicant which is lethal (fatal) to 50 percent of the organisms tested under the test conditions in a specified time. (From: Environmental Protection Agency. 1976. Quality Criteria for Water. United States Environmental Protection Agency, Washington, D.C. 256 pages.)

Continued...

TABLE 5.2 AMBIENT WATER STANDARDS (continued)

PARAMETER	PROTECTED USE	STANDARD IN GIVEN JURISDICTION				
		ALBERTA-SASKATCHEWAN ^{1,2,4,2}	BRITISH COLUMBIA ^{2,1-2,6}	ONTARIO ^{3,2}	CANADA-FEDERAL ^{5,4,5,5}	U.S. FEDERAL ^{6,1}
Lead	Aquatic life	-	-	0.005 - 0.025 mg/L depending on alkalinity	0.005 - 0.03 mg/L depending on species and hardness ^{5,4}	0.01 x 96-hr LC ₅₀ for fresh water
	Domestic supply	0.05 mg/L (Sask.)	0.05 mg/L ^{2,6}	0.05 mg/L max.	0.05 - 0.25 mg/L depending on treatment ^{5,4}	0.05 mg/L
	Livestock	-	-	0.1 mg/L	0.5 mg/L (horses); 1.0 mg/L (other) ^{5,4}	-
	Irrigation	-	-	5 - 10 mg/L	5.0 mg/L (continuous); 10.0 mg/L (intermittent) ^{5,4}	-
	Recreation General	- 0.05 mg/L	- No measurable change (all heavy metals) ^{2,1,2,5}	- -	0.05 mg/L ^{5,4} -	- -
Magnesium	Domestic supply	200 mg/L (Sask.)	-	-	150 mg/L ^{5,5}	-
Manganese	Domestic supply	0.05 mg/L (Sask.)	0.05 mg/L ^{2,6}	<0.05 mg/L desirable	0.05 mg/L ^{5,5}	0.05 mg/L
	Irrigation	-	-	0.2-10 mg/L	-	-
	Shellfish consumption	-	-	-	-	0.1 mg/L
	General	0.05 mg/L	-	-	-	-
Mercury	Aquatic life	-	-	0.0002 mg/L in filtered water	0.0001 mg/L where fish eaten ^{5,4}	0.0001 mg/L marine life 0.00005 mg/L freshwater
	Domestic supply	-	-	-	0.0002 mg/L where fish not eaten ^{5,4}	-
	Livestock	-	-	0.01 mg/L	0.001 mg/L ^{5,4}	0.002 mg/L
	Recreation	-	-	-	0.003 mg/L ^{5,4}	-
	General	0.0001 mg/L	No measurable change (all heavy metals) ^{2,1,2,5}	zero tolerance limit	0.001 mg/L ^{5,4} -	- -

Continued...

TABLE 5.2 AMBIENT WATER STANDARDS (continued)

		STANDARD IN GIVEN JURISDICTION					
PARAMETER	PROTECTED USE	ALBERTA-SASKATCHEWAN ^{1,2,4,2}	BRITISH COLUMBIA ^{2,1-2,6}	ON-TARIO ^{3,2}	CANADA-FEDERAL ^{5,4,5,5}	U.S. FEDERAL ^{6,1}	
Nickel	Aquatic life	-	-	0.025 mg/L	0.025 (soft water) 0.25 mg/L ^{5,4} (hardness >150 mg/L as CaCO ₃) 0.25 mg/L (conventional trt.) ^{5,4}	0.01 x 96-hr LC ₅₀	
	Domestic supply	-	-	-	-	-	
	Livestock	-	-	1.0 mg/L	5.0 mg/L ^{5,4}	-	
	Irrigation	-	-	0.2-2.0 mg/L	0.2 mg/L (continuous); 2.0 (intermittent) ^{5,4}	-	
	Recreation	-	-	-	0.25 mg/L ^{5,4}	-	
Selenium	Aquatic life	-	-	0.1 mg/L	0.01 mg/L ^{5,4}	0.01 x 96-hr LC ₅₀ for sensitive species	
	Domestic supply	0.01 mg/L (Sask.)	0.01 mg/L ^{2,6}	0.01 mg/L	0.05-0.25 mg/L depending on trt. ^{5,4}	0.01 mg/L	
	Livestock	-	-	0.05 mg/L	0.02 mg/L min; 0.05 mg/L max ^{5,4}	-	
	Irrigation	-	-	0.02 mg/L	0.02 mg/L continuous; 0.05 mg/L intermittent ^{5,4}	-	
	Recreation	-	-	-	0.05 mg/L ^{5,4}	-	
Silver	General	0.01 mg/L	-	-	-	-	
	Aquatic life	-	-	0.0001 mg/L	0.0001 mg/L ^{5,4}	0.01 x 96-hr LC ₅₀ for sensitive species	
	Domestic supply	0.05 mg/L (Sask.)	0.05 mg/L ^{2,6}	0.05 mg/L	0.05-0.2 mg/L depending on trt. ^{5,4}	0.05 mg/L	
	Recreation	-	-	-	0.05 mg/L ^{5,4}	-	
	General	0.05 mg/L	No measurable change (all heavy metals) ^{2,1,2,5}	-	-	-	

Continued...

TABLE 5.2 AMBIENT WATER STANDARDS (continued)

PARAMETER	PROTECTED USE	STANDARD IN GIVEN JURISDICTION				
		ALBERTA-SASKATCHEWAN ¹	BRITISH COLUMBIA ²	ONTARIO ³	CANADA-FEDERAL ^{5,4,5.5}	U.S. FEDERAL ^{6,1}
Sodium	General	30-75% of cations (chiefly for irrigation)	-	-	-	-
	Aquatic life	-	-	0.03 mg/L	0.05 mg/L (hardness <120 mg/L) to 0.30 mg/L (hardness >300 mg/L) ^{5.4}	0.1 x 96-hr LC ₅₀ for sensitive species
Zinc	Domestic supply	5.0 mg/L (Sask.)	2.6 5.0 mg/L	5.0 mg/L	5.0-10.0 mg/L depending on trt. ^{5.4}	5 mg/L
	Livestock	-	-	0.1 mg/L	50 mg/L ^{5.4}	-
	Irrigation	-	-	2.0-10 mg/L	1.0 mg/L (soil pH < 6.5) to 5.0 mg/L (soil pH > 6.5) ^{5.4}	-
	Recreation	-	-	-	5.0 mg/L ^{5.4}	-
	General	0.05 mg/L	-	-	-	-
INORGANIC NONMETALS:						
Alkalinity	Aquatic life	-	-	75% of natural value	-	20 mg/L as CaCO ₃
	Domestic supply	500 mg/L (Sask.)	-	-	-	-
	General	-	≥20% of natural value ^{2.4}	-	-	-
Boron	Domestic supply	5.0 mg/L (Sask.)	5.0 mg/L ^{2.6}	-	5.0 mg/L ^{5.5}	-
	Livestock	-	-	5.0 mg/L	-	-
	Irrigation	-	-	0.75-2.0 mg/L	-	0.75 mg/L for sensitive crops
	General	0.5 mg/L	-	-	-	-
Chloride	Domestic supply	250 mg/L (Sask.)	250 mg/L ^{2.6}	-	250 mg/L ^{5.5}	-
	General	-	25 mg/L ^{2.4}	-	-	-

Continued...

TABLE 5.2 AMBIENT WATER STANDARDS (continued)

PARAMETER	PROTECTED USE	STANDARD IN GIVEN JURISDICTION				
		ALBERTA-SASKATCHEWAN ¹ 2,4,2	BRITISH COLUMBIA 2.1-2.6	ONTARIO 3.2	CANADA-FEDERAL 5.4,5.5	U.S. FEDERAL 6.1
Chlorine residual	Aquatic life	-	-	0.002 mg/L	-	0.002 mg/L for salmonids; 0.010 mg/L for other organisms
Cyanide	General	-	Not detectable ^{2,1,2,2,2,3,2,5} †	-	-	-
	Aquatic life	-	-	0.005 mg/L (free)	-	-
	Domestic supply	0.01 mg/L (Sask.)	0.20 max. permissible ^{2,6}	0.01 mg/L desirable; 0.2 max.	0.01 mg/L acceptable; 0.20 mg/L max. permissible ^{5,5}	0.005 mg/L
Fluoride	General	0.01 mg/L	-	-	-	-
	Domestic supply	1.5 mg/L (Sask.)	1.5 mg/L ^{2,6}	1.2 mg/L when naturally present; 2.4 mg/L max.	1.2 ± 0.1 mg/L acceptable 1.5 mg/L max. ^{5,5}	-
Livestock	-	-	-	2.0 mg/L	-	-
Irrigation	-	-	-	1.0-15.0 depending on time & pH	-	-
Gases, dissolved	General	1.5 mg/L	-	-	-	-
	Aquatic life	-	-	110% saturation	-	110% saturation at existing atmosphere & hydrostatic pressure
Nitrogen total	General	1.0 mg/L	-	-	-	-
Nitrogen ammonia	Aquatic life	-	-	0.02 mg/L (un-ionized)	-	0.02 mg/L
Nitrogen nitrate	Domestic supply	-	0.5 mg/L as N ^{2,6}	-	0.5 mg/L (un-ionized) ^{5,5}	-
	Domestic supply	-	-	10 mg/L	-	10 mg/L

Continued...

† Most sensitive APHA standard methods can detect approximately 10 micrograms per liter (0.01 mg/L).

TABLE 5.2 AMBIENT WATER STANDARDS (continued)

STANDARD IN GIVEN JURISDICTION						
PARAMETER	PROTECTED USE	ALBERTA-SASKATCHEWAN ¹ .2,4,2	BRITISH COLUMBIA ² .1-2.6	ONTARIO ³ .2	CANADA-FEDERAL ⁵ .4,5.5	U.S. FEDERAL ⁶ .1
Nitrogen, nitrate & nitrite	Domestic supply	40 mg/L (Sask.)	10 mg/L ^{2.6}	-	10 mg/L ^{5.5}	-
	Livestock	-	-	100 mg/L	-	-
	Aquatic life	-	-	4-7 mg/L for warm-water biota, depending on temp.	> 50% seasonal max., depending on degree of protection ^{5.5}	5.0 mg/L for freshwater life & salmonid spawning beds
	Oxygen, dissolved	-	-	5-8 mg/L for cold-water biota, depending on temp.	-	-
pH	General	5 mg/L at any time	90% of seasonal natural value; 2.1, 2.2, 2.4, 2.5 negligible change ^{2.3}	-	-	-
	Aquatic life	-	-	6.5-8.5	6.0-9.0 (high protection) ^{5.5}	6.5-9 (freshwater); 6.5-8.5 (marine)
	Domestic supply	-	2.6 6.5-8.3	-	6.5 - 8.3 ^{5.5}	5-9
	Recreation (contact)	-	-	-	6 - 9 ^{5.5}	-
	Fish production	-	-	-	6.5 - 8.5 ^{5.5}	-
Phosphorus	General	6.5-8.5 & not more than ± 0.5 from background	no or negligible change ^{2.1-2.4}	-	-	-
	Aquatic life	-	-	-	-	0.0001 mg/L elemental
	Domestic supply	-	-	-	0.2 mg/L as P_{O_4} ^{5.5}	-
	Eutrophication avoidance	-	-	0.01-0.02 mg/L (tentative)	Vollenweider loading formula, ref. 5.5, page 123	-
	General	0.15 mg/L as P_{O_4}	No detectable change if limiting nutrient ^{2.3,2.5}	-	-	-
Sulphate	Domestic supply	500 mg/L (Sask.)	500 mg/L ^{2.6}	250 mg/L	500 mg/L ^{5.5}	-
Sulphide	Aquatic life	-	-	0.002 mg/L H_2S	-	0.002 mg/L H_2S
	Domestic supply	-	0.05 mg/L H_2S ^{2.6}	-	0.3 mg/L ^{5.5} as H_2S	-
	General	0.05 mg/L	Negligible increase ^{2.3}	-	-	-

Continued...

TABLE 5.2 AMBIENT WATER STANDARDS (continued)

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STANDARD IN GIVEN JURISDICTION							
PARAMETER	PROTECTED USE	ALBERTA-SASKATCHEWAN ^{1,2,4,2}	BRITISH COLUMBIA ^{2,1-2,6}	ONTARIO ^{3,2}	CANADA-FEDERAL ^{5,4,5,5}	U.S. FEDERAL ^{6,1}	
ORGANICS:							
	Carbon-chloro- form ex- tract	Domestic supply General	0.2 mg/L (CCE+CAE) [#] (Sask.) 0.2 mg/L	0.2 mg/L (CCE+CAE) ^{#2,6} -	0.2 mg/L -	0.2 mg/L ^{5,5} -	- -
	Grease and oil	Aquatic life	-	-	-	-	0.1x96-hr LC ₅₀ for sensitive species
		Domestic supply Fish consumption General	- - Substantially absent; none visible	- - No visible concentration ^{2,3,2,5,2,6}	- - No tainting	- -	- -
Mercaptans	General	0.05 mg/L (methyl) Application <1/100TL _m [†] (48 hr)	Negligible increase ^{2,3} -	-	-	-	-
Pesticides	General						
Chlorin- ated phenoxy- acid: 2,4-D	Aquatic life Domestic supply	- -	- 0.100 mg/L (for all herbicides) ^{2,6}	0.004 mg/L -	- 0.1 mg/L (for 2, 4-D+2,4, 5-T+2,4,5-TP) ^{5,5}	- 0.100 mg/L	- 0.100 mg/L
2,4,5-TP	Domestic supply	-	0.100 mg/L (as above) ^{2,6}	-	0.1 mg/L (as above) ^{5,5}	0.0100 mg/L	
Organo- chlorine: Aldrin	Aquatic life Domestic supply Livestock	- - -	- 0.017 mg/L ^{2,6} -	0.000001 mg/L - 0.001 mg/L	- -	0.000003 mg/L (w/dieldrin) -	- -

Sum of carbon chloroform and carbon alcohol extractables.

† TL_m: Median Tolerance Limit: The concentration of a test material at which just 50 percent of the test animals are able to survive under test conditions for a specified period of exposure. (From: Environmental Protection Agency, 1976. Quality Criteria for Water. United States Environmental Protection Agency, Washington, D.C. 256 pages.)

Continued...

TABLE 5.2 AMBIENT WATER STANDARDS (continued)

PARAMETER	PROTECTED USE	STANDARD IN GIVEN JURISDICTION				
		ALBERTA-SASKATCHEWAN ¹ .2,4,2	BRITISH COLUMBIA ² .1-2.6	ONTARIO ³ .2	CANADA-FEDERAL ⁵ .4,5.5	U.S. FEDERAL ⁶ .1
Chlordane	Aquatic life	-	-	0.00006 mg/L	-	0.000004 mg/L (marine) 0.000001 mg/L (fresh-water)
	Domestic supply	-	0.003 mg/L ^{2.6}	-	0.003 mg/L ^{5.5}	-
	Livestock	-	-	0.003 mg/L	-	-
DDT	Aquatic life	-	-	0.000 003 mg/L	-	0.000 001 mg/L
	Domestic supply	-	0.042 mg/L ^{2.6}	-	0.042 mg/L ^{5.5}	-
	Livestock	-	-	0.05 mg/L	-	-
Dieldrin	Aquatic life	-	-	0.000 001 mg/L	-	0.000 003 mg/L (with aldrin)
	Domestic supply	-	0.017 mg/L ^{2.6}	-	0.017 mg/L ^{5.5}	-
	Livestock	-	-	0.001 mg/L	-	-
Endrin	Aquatic life	-	-	0.000002 mg/L	-	0.000 004 mg/L
	Domestic supply	-	0.001 mg/L ^{2.6}	-	0.001 mg/L ^{5.5}	0.0002 mg/L
	Livestock	-	-	0.0005 mg/L	-	-
Heptachlor	Aquatic life	-	-	0.000 001 mg/L	-	0.000 001 mg/L
	Domestic supply	-	0.018 mg/L ^{2.6}	-	0.018 mg/L ^{5.5}	-
	Livestock	-	-	0.0001 mg/L	-	-
Lindane	Aquatic life	-	-	0.000 01 mg/L	-	0.000 01 mg/L (freshwater)
	Domestic supply	-	0.056 mg/L ^{2.6}	-	0.056 mg/L ^{5.5}	0.000 004 mg/L (marine)
	Livestock	-	-	0.005 mg/L	-	0.004 mg/L
Methoxy-chlor	Aquatic life	-	-	0.000 04 mg/L	-	0.000 03 mg/L
	Domestic supply	-	0.035 mg/L ^{2.6}	-	0.035 mg/L ^{5.5}	0.1 mg/L
	Livestock	-	-	1.0 mg/L	-	-

Continued...

TABLE 52 AMBIENT WATER STANDARDS (continued)

PARAMETER	PROTECTED USE	STANDARD IN GIVEN JURISDICTION				
		ALBERTA-SASKATCHEWAN ¹ 2,4,2	BRITISH COLUMBIA ² 1-2,6	ONTARIO ³ 2	CANADA-FEDERAL ⁵ 4,5,5	U.S. FEDERAL ⁶ 1
Toxaphene	Aquatic life	-	-	0.000 008 mg/L	-	0.000 005 mg/L
	Domestic supply	-	0.005 mg/L ^{2,6}	-	0.005 mg/L ^{5,5}	0.005 mg/L
Organo-phosphates	Livestock	-	-	0.005 mg/L	-	-
	Domestic supply	-	0.100 mg/L (incl. carbamates) ^{2,6}	-	-	-
Guthion	Livestock	-	-	0.1 mg/L (incl. carbamates)	-	-
	Aquatic life	-	-	0.000 005 mg/L	-	0.000 01 mg/L
Malathion	Aquatic life	-	-	0.0001 mg/L	-	0.0001 mg/L
Parathion	Aquatic life	-	-	0.000 008 mg/L	-	0.000 04 mg/L
Phenolic substances	Domestic supply	0.001 mg/L (Sask.)	0.002 mg/L ^{2,6}	0.001 mg/L	0.002 mg/L (as pheno) ^{5,5}	0.001 mg/L
Fish edibility	Fish edibility	-	-	0.001 mg/L	-	0.001 mg/L
	General	0.005 mg/L (0.0005 Sask.)	0.001 ^{2,1}	-	-	-
Polychlorinated biphenyls	Aquatic life	-	-	0.000 001 mg/L	-	0.000 001 mg/L
Resin acids	General	0.1 mg/L	-	-	-	-
Surfactants**	Domestic supply	0.5 mg/L MBAS (Sask.)	0.5 mg/L ^{2,6}	0.5 mg/L ABS	0.5 mg/L as MBAS ^{5,5}	-
	Recreation (contact)	-	-	-	2.0 mg/L as ABS equiv. ^{5,5}	-
	General	0.5 mg/L	-	-	-	-

** MBAS = methylene blue active substances, i.e., any anionic surface-active agents that react with methylene blue dye to form the methylene blue complex.

ABS = alkylbenzene sulfonate.

Continued...

TABLE 5.2 AMBIENT WATER STANDARDS (continued)

		STANDARD IN GIVEN JURISDICTION					
CONTAMINANT	PROTECTED USE	ALBERTA-SASKATCHEWAN	BRITISH COLUMBIA	ONTARIO	CANADA-FEDERAL	U.S. FEDERAL	
		1.2.4.2	2.1-2.6	3.2	5.4,5.5		
RADIOACTIVITY:							
Total	Domestic supply	-	ICRP occupational for 2.6 168 hr wk	-	5.5 10 pCi/L	-	
	Recreation	-		-	5.5 10 pCi/L	-	
	General (incl. drinking)	1,000 pCi/L		1,000 pCi/L	-	-	
	Radium 226	3 pCi/L		3 pCi/L	-	-	
Strontium 90	General (incl. drinking)	10 pCi/L	-	10 pCi/L	-	-	
MICROBIOLOGY:							
Coliforms, fecal	Domestic supply	1000/100 mL before trt.	-	-	100/100 mL before trt. acceptable 1000/100 mL before trt. max. 5.5	-	
	Recreation (contact)	200/100 mL	-	100/100 mL geometric mean	200/100 mL 5.5	200/100 mL log mean	
Coliforms, total	Irrigation	200/100 mL	-	-	-	-	
	Shellfish harvesting	-	14/100 mL 2.5	-	-	14/100 mL	
	General	-	200/100 mL 2.5	-	-	-	
	Domestic supply	5000/100 mL before trt.	-	-	1000/100 mL before trt. acceptable 5000/100 mL before trt. max. 5.5	-	
General	Recreation (contact)	1000/100 mL	-	1000/100 mL geometric mean	500/100 mL 5.5	-	
	General	-	1000 100 mL 2.6	-	-	-	

iron, lead, manganese, silver, and zinc. In addition, the provincial and U.S. standards are in accord for chromium, selenium, and copper, with the Canadian Federal limit being somewhat different. Aquatic life is generally the most sensitive use and here the situation is less uniform. The jurisdictions having separate limits for protection of aquatic life tend to allow only very low concentrations of the heavy metals. Alberta and Saskatchewan, on the other hand, have a general standard that is intended to protect aquatic life as well as less sensitive uses, but this standard does not approach the stringency of the standards set by Ontario and the Canadian Federal government for such metals as cadmium, copper, lead, and silver. Alberta and Saskatchewan's limits are equal to, or more stringent than, the Canadian Federal limits for chromium, mercury, and selenium.

Coverage of the inorganic nonmetals in published standards is not uniform. Many of the parameters are mentioned by only a few jurisdictions. Drinking water limits are the same or very close, among the jurisdictions having such limits, for boron, chloride, cyanide, ammonia nitrogen, and fluoride. Here, again, the general limits set by Alberta and Saskatchewan for cyanide and sulphide appear to be less stringent than those set for other jurisdictions for aquatic life. The aquatic life values set by Ontario are identical with those established by the U.S. for cyanide, dissolved gases, ammonia nitrogen, and sulphide, as well as residual chlorine. The latter parameter is an important omission from the standards of all the other jurisdictions studied. Fish are very sensitive to chlorine, which is contained in the effluents of wastewater treatment plants practicing conventional disinfection. For the very critical parameter of dissolved oxygen, the approaches used by the jurisdictions vary, but all recommend values equal to or exceeding 5 mg/l, especially for the salmonid or cold-water-type fishes.

For organic materials, approaches also vary. For domestic supply, the values given by the various jurisdictions are the same for carbon-chloroform extract and surfactants. Alberta and Saskatchewan have a general standard for pesticides that specifies 0.01 of the 48-hour median tolerance limit, whereas the other jurisdictions have specific concentration values for specific pesticides. While the general approach has the virtue of apparent simplicity, it also has several shortcomings. First, the general standard gives the illusion that all possible pesticides are covered, but this is much more in theory than in practice, because in many cases a value for the median tolerance limit may not be known. The presumption is that tests would be conducted or that values would be obtained from the literature. However, information on the effects of pesticides, especially under Canadian

conditions, is not abundant. The other major shortcoming of the general type of standard is that it focuses on only one type of effect, namely, death of aquatic organisms. It gives no information about protection against sublethal effects, such as impairment of reproductive success. With a substance-concentration-specific approach, the regulatory authority can decide what sublethal effects it wishes to avert and can decide what standard gives an appropriate margin of safety. For domestic supply, British Columbia and Canadian Federal limitations are the same. Aquatic life, however, is a more sensitive use, and the limitations set by Ontario are more complete, at least for the well-known pesticides listed here, and tend to be very close to the values recommended by the U.S. The same is true of phenolics and polychlorinated biphenyls.

Alberta, Saskatchewan, and Ontario have identical limits for radioactivity parameters.

The microbiological parameters of total coliforms and fecal coliforms are treated similarly by most jurisdictions. For domestic supply, Alberta and Saskatchewan, and the Canadian Federal government have the same maximum limit for waters prior to treatment for domestic use. Recommendations for contact recreation are considerably more stringent and largely uniform, although Ontario's fecal coliform value and the Canadian total coliform value are more restrictive than those of the other jurisdictions. In addition, British Columbia and the U.S. Federal government have special fecal coliform standards for shellfish harvesting. These are identical.

CHAPTER 6

EFFLUENT LIMITATIONS FOR CASE-STUDY INDUSTRIES

This chapter examines the effluent limitations set by the study provinces and the Canadian and U.S. Federal governments for the case-study industries. Each section describes the processes involved in the industry, the sources of air and water pollutants, and the control options available. Compilations of the air and water effluent limits for the various jurisdictions are presented in tabular form,* and observations are made about the structure of the limitations and comparisons are made of the values given.

In this chapter, the word "standard" is used in the inclusive sense in which it is used in Chapter 2, that is, it includes values that are standards in the legal sense (legally enforceable) but also standard-like values that represent officially endorsed goals.

A few jurisdictions have several levels of effluent standards and these should be explained at the outset. British Columbia has three levels, defined as follows:

- A - objective for all new and proposed discharges, and long-range goal for existing operations;
- B - intermediate objective for all existing discharges within a specified period and immediate goal for modified or increased existing discharges;
- C - immediate objective for all existing discharges within minimum technically feasible period.

The U.S. also designates several levels for waterborne effluents. These are technology-based standards, that is, they are based on what can be achieved by various treatment methods with respect to effluent quality, rather than on contribution of pollutants to the receiving water. These are as follows: Best practicable control technology currently available - abbreviated BPT in the tables - is the level

* Reference numbers in all tables of this chapter refer to the list entitled "Standards Sources", following the chapter.

originally mandated for achievement by 1977 and now applying to conventional pollutants by July 1, 1984.

Best available technology economically achievable (BAT) was originally set as a general goal for 1983. It now applies to nonconventional pollutants, although variances may be sought, by July 1, 1984, but no later than July 1, 1987, and to toxic pollutants, with no variances available.

The airborne emissions standards for the province of Ontario are different in form from those of the other study jurisdictions, are applicable to all types of industry, and are in terms of concentration at point of impingement rather than point of emission. They therefore are not directly comparable to the other emission limits studied. A partial listing of the Ontario standards is given in Table 6.0.

PETROLEUM REFINERIES

Processes and Wastes

Petroleum refineries are enormously complex and the briefest overview of the various process components as sources of air and waterborne wastes must suffice here as background to the discussion of the standards.

The basic processes of oil refining consist of separating the crude oil into selected fractions according to boiling range in fractionation towers; conversion of some streams to other products by splitting, rearranging, or joining their molecules by the catalytic processes of cracking, reforming, and polymerization, respectively; treatment to remove minor constituents detrimental to product quality; and blending to produce the desired mix of final products.

The fractionation columns, and the crude desalting that precedes them, emit wastewaters high in pH and containing ammonia, cyanides, phenolics, sulphur-containing compounds, and oily constituents. These streams join with other process wastewaters for treatment, after stripping for removal of ammonia, sulphides, and mercaptans, which gases pass to the sulphur recovery unit.

The steam plant contributes particulates to the plant's airborne emissions. Particulate emission can be controlled very

Table 6.0 -- Ontario Air Emission Standards
(Partial Listing)

Parameter	Concentration at Point of Impingement (1/2-hour average)
Carbon monoxide	6,000 $\mu\text{g}/\text{m}^3$ air
Chlorine	300 $\mu\text{g}/\text{m}^3$ air
Chlorine dioxide	85 $\mu\text{g}/\text{m}^3$ air
Fluorides (total)	8.6 $\mu\text{g}/\text{m}^3$ as HF, Apr. 15 - Oct. 15 17.2 $\mu\text{g}/\text{m}^3$ as HF, Oct. 16 - Apr. 14
Hydrocarbons	No collective limit
Hydrogen chloride	100 $\mu\text{g}/\text{m}^3$ air
Mercury (total)	5.0 $\mu\text{g}/\text{m}^3$ air
Nitrogen oxides	500 $\mu\text{g}/\text{m}^3$ air as NO_2
Particulates (suspended)	100 $\mu\text{g}/\text{m}^3$ air
Sulphur dioxide	830 $\mu\text{g}/\text{m}^3$ air
Sulphuric acid	100 $\mu\text{g}/\text{m}^3$ air

effectively by the use of cyclones. Blowdown water from the steam plant contains suspended solids as well as biochemical oxygen demand, and is treated with other refinery process water.

Other process units have aqueous effluents containing oily constituents. Airborne effluents from regeneration of catalysts are an important source of particulates, as well as of carbon monoxide.

Storage, loading, and flares give off airborne hydrocarbons and may be important sources of odour.

Product treatment processes, especially those for removal of sulphur from refinery products, give rise to gaseous sulphur-containing compounds that can be treated in the sulphur recovery unit.

The waterborne wastes from the refinery are generally treated by separation for oil removal and reduction of suspended solids, dissolved-air flotation for further oil removal, and biological treatment to reduce oxygen demand.

Comparison of Standards

Airborne Emissions. Table 6.1 shows the published airborne effluent limitation for petroleum refineries. The province of Alberta has, as yet, no specific limitations for this industry. The values given for visible and particulate emissions in the Clean Air (Maximum Levels) Regulations, however, are given. Emission standards for other parameters such as sulphur dioxide are not mentioned in these regulations. British Columbia's limitations are detailed, not only prescribing limits for a number of parameters, but also setting these limits on a process unit-by-process unit basis. Neither Saskatchewan nor the Canadian Federal government appears to have standards governing this industry. The U.S. Federal government has issued limits for a number of pollutants.

The standards for particulate emissions for Alberta and British Columbia are similar. Comparison of the standards for British Columbia with those of the U.S. indicates that those of the U.S. are somewhat more stringent, especially that for carbon monoxide.

TABLE 6.1 EFFLUENT LIMITATIONS FOR PETROLEUM REFINERIES - AIR

Parameter	Limitation in Given Jurisdiction					
	Alta. 1.1	B.C. 2.1	Ont. 3.5	Sask.	Can. Fed.	U.S. Fed. 6.4
Opacity	<40% avg. over 6 conseq min.	-	<20%	-	-	<30%, except for one 6-min period per hour
Particulates: General	0.20 lb/1,000 lb effluent $\pm$ 0.11 gr/scf air	-	see Table 6.0	-	-	-
FCCU regenerator	-	A-115 mg/m ³ (0.050 gr/scf) B-345 mg/m ³ (0.150 gr/scf) C-690 mg/m ³ (0.300 gr/scf)	-	-	-	1.0 kg/1,000 kg coke burnoff rate (formula given)
Steam plant	-	A-150 mg/m ³ (0.065 gr/scf) B-200 mg/m ³ (0.087 gr/scf) C-300 mg/m ³ (0.130 gr/scf)	-	-	-	-
Carbon monoxide: General	-	-	see Table 6.0	-	-	0.050% by volume = 500 ppm
FCCU regenerator	-	A-2400 mg/m ³ (2,000 ppm) B-2400 mg/m ³ (2,000 ppm) C-120,000 mg/m ³ (100,000 ppm)	-	-	-	-

Continued...

TABLE 6.1 EFFLUENT LIMITATIONS FOR PETROLEUM REFINERIES - AIR (continued)

Parameter	Limitation in Given Jurisdiction					
	Alta. 1.1	B.C. 2.1	Ont. 3.5	Sask.	Can. Fed.	U.S. Fed. 6.4
Sulphur dioxide:						
General	-	A-830 mg/m ³ (300 ppm)	see Table 6.0	-	-	0.025% by vol. w/oxidation control system or reduction control sys. w/incinerator
Sulphur plant	-	B.C.-to meet ambient standard				0.030% reduced S cpds. +0.001% H ₂ S as SO ₂ w/reduction control sys. w/o incin.
Steam plant and FCCU regenerator	-	A-830 mg/m ³ (300 ppm) B-1,650 mg/m ³ (600 ppm) C-2,800 mg/m ³ (1,000 ppm)	-	-	-	230 mg/H ₂ S (0.10 gr/dscf) in fuel content (steam plant only)
Sulphur trioxide (overall)	-	A-25 mg/m ³ (0.011 gr/scf) B-50 mg/m ³ (0.022 gr/scf) C-100 mg/m ³ (0.044 gr/scf)	-	-	-	-
Hydrocarbons	-	A-90 mg/m ³ (25 ppm) as hexane B-180 mg/m ³ (50 ppm) as hexane C-540 mg/m ³ (150 ppm) as hexane	see Table 6.0	-	-	-

Waterborne Emissions. Table 6.2 shows the published waterborne effluent limitations for the petroleum industry. Alberta, British Columbia, the Canadian Federal government, and the U.S. Federal government have detailed limitations. Ontario has adopted the Canadian Federal limits where they are more stringent than the general standards for all industry in the province. Because the Federal limits are on a unit-of-production basis and the Ontario limits generally on a concentration basis, the governing limit would have to be determined in each case on the basis of the relationship of effluent volume to production. Both sets of limits are given in the table. The U.S. limits are somewhat more complicated. The regulations state limits in terms of pollutant output per volume of oil, but these figures must be multiplied by two factors, one based on size of the refinery and the other on process configuration.

The U.S. figures presented in the table were arrived at as follows: The basic limit was multiplied by the lowest size factor and the lowest process configuration factor to give the minimum figure of the range, and by the highest size factor and highest process configuration factor to give the maximum figure of the range. Limits are given for both best practicable technology (BPT) and best available technology (BAT).

Coverage of the parameters of concern by the limits of the various jurisdictions is reasonably complete. Some Alberta refineries are able to dispose of some of their wastes by injection into suitable geological formations, and are therefore held to more stringent discharge standards than are refineries that do not have this capability. A survey of the limits for important parameters reveals that Alberta's standards for refineries without injection well disposal are identical with the Canadian Federal standards for new refineries (which also apply to Ontario). These are somewhat more lenient than the U.S. BAT standards and are similar to the U.S. BPT values (suspended solids, ammonia nitrogen, oil and grease, chemical oxygen demand). In certain cases they are considerably more lax than the U.S. BPT standard (sulphides, phenolics). In the latter cases, the standards for British Columbia are also considerably more stringent than the Canadian Federal values, being quite close to the U.S. limits. For the very important parameter of toxicity, Alberta and Ontario have adopted the Canadian Federal limit, which is comparable to British Columbia's A-level requirement for discharge to fresh water.

TABLE 6.2 EFFLUENT LIMITATIONS FOR PETROLEUM REFINERIES - WATER

Parameter	Limitation within Given Jurisdiction							
	Alta. 1.3*	B.C. 2.1††	5.8	Ontario	3.3	Sask.	Can. Fed. 5.8	U.S. Fed. 6.5 (Integrated subcategory)
PHYSICAL: Odor (TON)	With disposal wells: 300 monthly 400 daily 800 max. daily W/out disposal wells: 450 monthly 600 daily 1200 max. daily	-		-	-	-	-	-
Solids:								
Floatable	-	Negligible		-	-	-	-	-
Settleable	-	0.5 mg/L		-	-	-	-	-
Suspended, total	With disposal wells: 4.8 lb/MGPD monthly 8.0 lb/MGPD daily 10.0 " max.daily	A,B - 20 mg/L C - 30 mg/L		New refineries: 7.2 lb/1,000 bbl monthly 12.0 lb/1,000 bbl daily 15.0 lb/1,000 bbl max. daily	15mg/L	-	New refineries: 7.2 lb/1,000 bbl monthly 12.0 lb/1,000 bbl daily 15.0 lb/1,000 bbl max. day	3AT: 1.42-6.11 lb/1000 bbl monthly 1.64-7.05 lb/1,000 bbl max. day.
	W/out disposal wells: 7.2 lb/MGPD monthly 12.0 lb/MGPD daily 15.0 " max. daily			Existing refineries 14.4 lb/1,000 bbl monthly 24.0 lb/1,000 bbl daily 30.0 lb/1,000 bbl max. daily			Existing refineries: 14.4 lb/1,000 bbl monthly 24.0 lb/1,000 bbl daily 30.0 lb/1,000 bbl max. day	BPT: 4.60-19.74 lb/1,000 bbl monthly avg. 7.23-31.02 lb/1,000 bbl max. daily

... oil-well effluents are assumed to generate effluent at rate of 13.4 Can. gallons per minute per 1,000 barrels/day; refineries without

† $\text{mapp} = 1,000 \text{ barrels/day}$.

†† "A" level process effluent vol-
 ume/1,000 barrels per day.

Continued...

TABLE 6.2 EFFLUENT LIMITATIONS FOR PETROLEUM REFINERIES - WATER (continued)

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Parameter	Limitation within given Jurisdiction						
	1.3 Alta.	2.1 B.C.	5.8 Ontario	3.3	Sask.	Can. Fed. 5.8	U.S. Fed. 6.5
Solids, (cont.)							
Total	-	Marine: A,B,C - 3,000 mg/L Fresh water: A,B,C - 1,500 mg/L 90°F max.	-	-	-	-	-
Temperature	-						
Turbidity	-	Marine: A,B,C - 15 JTU Fresh water: A,B,C - 10 JTU	-	-	-	-	-
METALS:							
Chromium:							
Hexavalent	0.30 mg/L	-	-	-	-	-	BAT: 0.0011-0.0049 lb/ 1,000 bbl, monthly avg. 0.0018-0.0078 lb/ 1,000 bbl max. daily BPT: 0.0060-0.0259 lb/ 1,000 bbl monthly avg. 0.0137-0.0588 lb/ 1,000 bbl max. daily
Chromium, total	-	A,B,C - 0.2 mg/L	-	1.0 mg/L	-	-	BAT: 0.0711-0.3055 lb/1,000 bbl monthly avg. 0.0821-0.3525 lb/1,000 bbl max. daily BPT: 0.0323-0.1387 lb/1,000 bbl monthly avg. 0.1588-0.6815 lb/1,000 bbl max. daily
Copper	-	A,B,C - 0.1 mg/L	-	1.0 mg/L	-	-	-
Lead	0.10 mg/L	A,B,C - 0.2 mg/L	-	1.0 mg/L	-	-	-

Continued...

TABLE 8.2 EFFLUENT LIMITATIONS FOR PETROLEUM REFINERIES - WATER (continued)

Parameter	Limitation in Given Jurisdiction					
	1.3 Alberta	2.1 B.C.	5.8 Ontario	3.3 Sask.	5.8 Can. Fed.	6.5 U.S. Fed.
Mercury	0.0005 mg/L	-	-	-	-	-
Nickel	1.0 mg/L	A,B,C - 0.2 mg/L	-	-	-	-
Zinc	1.0 mg/L	Marine: A,B - 0.2 mg/L C - 0.3 mg/L Fresh water: A,B,C - 0.2 mg/L	-	-	-	-
INORGANIC NONMETALS:						
Cyanide	0.025 mg/L	A,B - 0.10 mg/L C - 0.20 mg/L	-	-	-	-
Nitrogen, ammonia	(12.5 mg/L) with disposal wells: 2.4 lb/MPO-monthly 3.4 " -daily 4.8 " max daily W/out disposal wells: 3.6 lb/MPO-monthly 5.7 " -daily 7.2 " max daily	A-0.576 lb/1,000 bbl B-1.87 C-15 mg/L	New: 3.6 lb/1,000 bbl monthly 5.7 lb/1,000 bbl daily 7.2 lb/1,000 bbl max day. Existing: 5.0 lb/1,000 bbl monthly 8.0 lb/1,000 bbl daily 10.0 lb/1,000 bbl max day	-	New: 3.6 lb/1,000 bbl monthly 5.7 lb/1,000 bbl daily 7.2 lb/1,000 bbl max day Existing: 5.0 lb/1,000 bbl monthly 8.0 lb/1,000 bbl daily 10.0 lb/1,000 bbl max day	BAT: 0.82-3.53 lb/1,000 bbl monthly avg. 1.10-4.7 lb/1,000 bbl max. daily BPT: 2.08-8.93 lb/1,000 bbl monthly avg. 4.54-19.5 lb/1,000 bbl max. daily
Oxygen, dissolved	-	Marine: A,B - > 1 mg/L C - - Fresh water: A - > 5 mg/L B,C - > 1 mg/L	-	-	-	-
pH (Units)	6.0 - 9.5	Marine: A - 6.5 - 8.5 B,C - 6.5 - 9.0 Fresh water: A,B - 6.5 - 8.5 C - 6.5 - 9.0	6.0 - 9.5	5.5-9.5	6.0-9.5	6.0-9.0
Phosphate	-	Marine: A,B,C - 3.0 mg/L Fresh water: A,B - 1.0 mg/L C - 3.0 mg/L	-	-	-	-

Continued

TABLE 6.2 EFFLUENT LIMITATIONS FOR PETROLEUM REFINERIES - WATER (continued)

Parameter	Limitation in Given Jurisdiction					
	Alberta 1.3	B.C. 2.1	5.8	Ontario 3.3	Sask. 5.8	U.S. Fed. 6.5
Sulphides	(0.35 mg/L) with disposal wells: 0.065 lb/MSPD monthly 0.20 lb/MSPD daily 0.33 lb/MSPD max. day	A-0.011 lb/1,000 bbl [†] B-0.02 mg/L C-1.0 mg/L	New: 0.1 lb/1,000 bbl monthly 0.3 lb/1,000 bbl daily 0.5 lb/1,000 bbl max. day Existing: 0.2 lb/1,000 bbl monthly 0.6 lb/1,000 bbl daily 1.0 lb/1,000 bbl max. day	-	New: 0.1 lb/1,000 bbl monthly 0.3 lb/1,000 bbl daily 0.5 lb/1,000 bbl max. day Existing: 0.2 lb/1,000 bbl monthly 0.6 lb/1,000 bbl daily 1.0 lb/1,000 bbl max. day	BAT: 0.023-0.099 lb/1,000 bbl monthly avg. 0.036-0.155 lb/1,000 bbl max. day. SPT: 0.031-0.132 lb/1,000 bbl monthly avg. 0.068-0.291 lb/1,000 bbl max. daily
	W/out disposal wells: 0.10 lb/MSPD monthly 0.30 lb/MSPD daily 0.50 lb/MSPD max day					
ORGANICS	Oil and grease (10 mg/L) W/out disposal wells: 2.0 lb/MSPD monthly 3.7 " daily 5.0 " max. day W/out disposal wells: 3.0 lb/MSPD monthly 5.5 " daily 7.5 " max. daily	Marine: A-1.15 lb/1,000 bbl total oil B-2.80 lb/1,000 bbl nonvolatile oil C-15 mg/L nonvolatile oil Fresh water: A-0.58 lb/1,000 bbl total oil B-2.80 lb/1,000 bbl nonvolatile oil C-15 mg/L nonvolatile oil	New: 3.0 lb/1,000 bbl monthly 5.5 lb/1,000 bbl daily 7.5 lb/1,000 bbl max. day Existing: 6.0 lb/1,000 bbl monthly 11.0 lb/1,000 bbl daily 15.0 lb/1,000 bbl max. day	15 ppm	Res: 3.0 lb/1,000 bbl monthly 5.5 lb/1,000 bbl daily 7.5 lb/1,000 bbl max. day Existing: 6.0 lb/1,000 bbl monthly 11.0 lb/1,000 bbl daily 15.0 lb/1,000 bbl max. day	BAT: 0.26-1.13 lb/1,000 bbl monthly avg. 0.33-1.41 lb/1,000 bbl max. daily SPT: 1.8-7.5 lb/1,000 bbl monthly avg. 3.3-14.1 lb/1,000 bbl max. daily
	Oxygen demand: Biochemical	A - 2.30 lb/1,000 bbl B.C-8.0 lb/1,000 bbl	-	15 mg/L	-	BAT: 1.4-6.1 lb/1,000 bbl monthly avg. 1.8-7.5 lb/1,000 bbl max. daily SPT: 5.6-24.0 lb/1,000 bbl monthly avg. 10.5-45.1 lb/1,000 bbl max. daily

[†] Includes mercaptans, all as S.

Continued.

TABLE 6.2 EFFLUENT LIMITATIONS FOR PETROLEUM REFINERIES - WATER (continued)

Parameter	Limitation in Given Jurisdiction									
	1.3 Alta.	B.C.	2.1	5.8	Ontario	3.3	Sask.	Can. Fed.	5.8	U.S. Fed.
Oxygen demand: Chemical	(200 mg/L) W/disposal wells: 40 lb/MBPD monthly 74 lb/MBPD daily 100 lb/MBPD max.day W/out disposal wells: 60 lb/MBPD monthly 110 " daily 150 " max. day	-	-	-	-	-	-	-	-	BAT: 7.3-31.5 lb/1,000 bbl monthly avg. 9.2-39.5 lb/1,000 bbl max. daily BPT: 33-165 lb/1,000 bbl monthly avg. 74-320 lb/1,000 bbl max. daily
Phenolics	(1 mg/L) W/disposal wells: 0.20 lb/MBPD monthly 0.37 " daily 0.50 " max.daily W/out disposal wells: 0.30 lb/MBPD monthly 0.55 " daily 0.75 " max. day	A-0.023 lb/1,000 bbl B-0.06 lb/1,000 bbl C-0.2 lb/1,000 bbl	A-0.023 lb/1,000 bbl B-0.06 lb/1,000 bbl C-0.2 lb/1,000 bbl	New: 0.3 lb/1,000 bbl monthly 0.55 lb/1,000 bbl daily 0.75 lb/1,000 bbl max. day Existing: 0.6 lb/1,000 bbl monthly 1.1 lb/1,000 bbl daily 1.5 lb/1,000 bbl max. day	20 ppb	-	-	New sources: 0.3 lb/1,000 bbl monthly 0.55 lb/1,000 bbl daily 0.75 lb/1,000 bbl max. day Existing: 0.6 lb/1,000 bbl monthly 1.1 lb/1,000 bbl daily 1.5 lb/1,000 bbl max. day	BAT: 0.005-0.024 lb/1,000 bbl monthly avg. 0.008-0.035 lb/1,000 bbl BPT: 0.037-0.160 lb/1,000 bbl max. day monthly avg. 0.077-0.329 lb/1,000 bbl max. daily	
TOXICITY †	see Can. Fed.	Marine: A-75%, 96-hr TL _m B-50%, " C- 5%, " Fresh water: A-100%, 96-hr TL _m B- 75%, " C- 5%, "	see Can. Fed.	see Can. Fed.	see Can. Fed.	Refineries dis- charging > 20 Can. gpm/1,000 bbl crude per day: 100%, 96-hr TL _m Refineries dis- charging < 20 Can. gpm/1,000 bbl crude per day: $\frac{Q}{20} \times 100\%$, 96-hr TL _m ; with $\frac{Q}{20}$ limited to $\frac{1}{3}$	-	-		

† Values given are percentages of undiluted effluent in which 50% fish mortality takes place over a 96 hr. period. Thus, 100% means that half the test fish die over 96 hours in full-strength (100%) effluent, whereas 50% means that half the test fish die over 96 hours in effluent diluted 1:1 with control test water.

CHEMICAL PLANTS

Because of the very great variety of chemical plants and the scarcity of specific standards covering particular types, this component of the study has been limited to three specific types: the chlor-alkali industry, the fertilizer industry, and the polyvinyl chloride manufacturing industry.

Chlor-alkali Industry

Processes and Pollutants. Chlorine and caustic soda (sodium hydroxide) are produced together by the electrolytic decomposition of brine. After the brine is treated to remove undesirable substances, it is decomposed in one of two types of electrolytic cells: a diaphragm cell or a cell using a moving mercury cathode. In either case, the products are chlorine gas, which is subsequently liquefied, caustic soda, which is sold in the form of a strong solution, and hydrogen gas. The hydrogen may be vented, used as fuel, or reacted with chlorine to produce hydrochloric acid.

In processes using mercury cells, mercury is the potential air and water pollutant causing the greatest concern. Mercury in the hydrogen vent and cell ventilation system can be controlled by cooling and condensing the mercury vapour followed by an entrainment separation. Mercury in waterborne waste streams can be precipitated as sulphide and removed by filtration. Chlorine in airborne effluents arises from residuals remaining in the liquefaction step and other sources and can be removed by scrubbing with caustic soda. Lead, formerly of concern in the diaphragm cell process, has been phased out.

Comparison of Standards. Table 6.3 shows the limitations for discharges to air. Only British Columbia has extensive standards for this industry with respect to airborne effluents, although both the Canadian and U.S. Federal governments have standards for mercury. In this case, the Canadian Federal limit is considerably more stringent than the British Columbia limit. Another clause in the Canadian Federal regulations limits the total mercury output to air to 1.68 kg/day, which, being equal to 1,680 g/day, appears also to be more stringent than the U.S. requirement. Alberta's general emission standards for opacity and particulates are applicable.

The situation with respect to waterborne effluents (Table 6.4) is quite different. For mercury, Ontario's general

TABLE 6.3 EFFLUENT LIMITATIONS FOR SELECTED POLLUTANTS FROM SELECTED CHEMICAL INDUSTRIES - AIR

Industry	Parameter	Limitation in Given Jurisdiction					
		Alberta 1,1,1,4	B.C.2,1	Ontario 3,5	Sask.	Can. Fed. 5,9,5,10	U.S. Fed. 6,6-6,10
Chlor-alkali	Chlorine	-	A-15mg/m ³ (5 ppm) B-30 " (10 ppm) C-300 " (100 ppm)	see Table 6.0	-	-	-
	Chlorine dioxide	-	A-9mg/m ³ (3 ppm) B-30 " (10 ppm) C-125" (45 ppm)	see Table 6.0	-	-	-
	Hydrogen chloride	-	A,B-70mg/m ³ (50 ppm) C-140 " (150 ppm)	see Table 6.0	-	-	-
	Mercury	-	A-0.0200 lb/ton Cl produced B,C -0.026 lb/ton Cl produced	see Table 6.0	-	5g/day/1,000 kg capacity-cell rooms ^{5,9} 0.1g/day/ 1,000 kg-other	2,300g/24 hr ^{6,6}
Fertilizer & related: Sulfuric acid	Particulates	0.20 lb/1,000 lb effluent ^{1,1}	A-230 mg/m ³ (0.100 gr/scf) B-345 mg/m ³ (0.150 gr/scf) C-575 mg/m ³ (0.250 gr/scf)	see Table 6.0	-	-	-
	SO ₂	4 lb/ton 100% acid produced ^{1,4} 6 lb/ton 24-hr avg. operating 0.20 ppm v-max.cum. 1/2 hr calc.ground. level conc.	A-3.0 lb/ton 100% acid B-10 lb/ton 100% acid C-25 lb/ton 100% acid	see Table 6.0	-	-	4 lb/ton 100% acid produced ^{6,7}
	SO ₃ + H ₂ SO ₄ mist	0.15 lb/ton produced 24-avg. ^{1,4}	SO ₃ : A-25 mg/m ³ (0.011 gr/scf) B-50 mg/m ³ (0.022 gr/scf) C-100 mg/m ³ (0.043 gr/scf)	see Table 6.0	-	-	0.15 lb H ₂ SO ₄ /ton produced ^{6,7}

Continued...

TABLE 6.3 EFFLUENT LIMITATIONS FOR SELECTED POLLUTANTS FROM SELECTED CHEMICAL INDUSTRIES - AIR (continued)

Industry	Parameter	Limitation in Given Jurisdiction				
		Alberta 1.1, 1.4	B.C. 2.1	Ontario 3.5	Sask.	Can. Fed. 5.9, 5.10
Vinyl chloride	Vinyl chloride	10 ppm 0.002-0.2 kg/100 kg PVC for various processes ^{1.1}	-	-	-	10 ppm 0.002-0.2 kg/100 kg PVC for various processes
	Nitrogen oxides (as NO ₂)	New plants: 3 lb/ton 100% acid produced, 1.4 design 4.5 lb/ton 24 hr avg 5.5 lb/ton 1/2 hr avg Existing plants: 7 lb/ton 100% acid produced, design 10 lb/ton 24-hr avg. 12 lb/ton 1/2-hr avg. 0.20 ppm -max.cum. 1/2-hr calc. ground level conc.	A-5.0 lb/ton 100% acid B-20 lb/ton 100% acid C-60 lb/ton 100% acid	see Table 6.0	-	5.10 10 ppm 0.002-0.2 kg/100 kg PVC for various processes
Phosphate fertilizer	Fluoride	Phosphoric acid plants: 0.025 lb/ton P ₂ O ₅ daily avg. soluble, as HF Ammonium phosphate plants: New: 0.03 lb/ton product daily avg. Existing: 0.05 lb/ton, daily avg, as HF 5.0 ppb _v	A-0.2 lb/ton, total, as SiF ₄ 4.3 mg/m ³ (6.4ppm) as HF B-0.3 lb/ton, total, as SiF ₄ 4.3 mg/m ³ (6.4ppm) as HF C-0.8 lb/ton total, as SiF ₄ 4.3 mg/m ³ (6.4 ppm) as HF	see Table 6.0	-	10 ppm 0.002-0.0004 lb/lb for various processes ^{5.10} (=0.002-0.04 kg/100 kg 3.0 lb/ton 100% acid ^{6.8}
						Phosphoric acid plants (wet process): 0.02 lb/ton P ₂ O ₅ , total Diammonium phosphate plants: 0.06 lb/ton P ₂ O ₅ ^{6.9}

TABLE 6.4 EFFLUENT LIMITATIONS FOR SELECTED POLLUTANTS FROM SELECTED CHEMICAL INDUSTRIES - WATER

Industry	Parameter	Limitation in Given Jurisdiction				
		Alberta 1.5	B.C. 2.1	Ontario 3.3	Sask.	Can. Fed. 5.11
Chlor-alkali	Suspended solids	-	Marine & fresh waters: A,B - 20 mg/L C - 30 mg/L	15 ppm _w	-	-
	Lead (diaphragm cell process)	-	Marine & fresh waters: A,B,C - 0.2 mg/L	1.0 mg/L	-	-
	Mercury (Hg cell process)	-	Marine & fresh waters: A - 0.002 mg/L B,C - 0.050 mg/L	0.001 mg/L (essentially zero)	-	0.00250 kg/tonne prod. 5.11 (0.019 mg/L @ 35,000 gal/ton Cl)
	pH	-	Marine: A - 6.5-8.5 B,C - 6.5-9.0 Fresh water: A,B - 6.5-8.5 C - 6.5-9.0	5.5 - 9.5	-	-

Continued...

TABLE 8.4 EFFLUENT LIMITATIONS FOR SELECTED POLLUTANTS FROM SELECTED CHEMICAL INDUSTRIES - WATER (continued)

Industry	Parameter	Limitation in Given Jurisdiction				
		Alberta 1.5	B.C. 2.1	Ontario 3.3	Sask.	Can. Fed. 5.11
Fertilizer & related	Suspended solids	25 mg/L	Marine & fresh waters: A,B - 20 mg/L C - 30 mg/L	15 ppm _w	-	-
	Cyanide	0.025 mg/L	A,B - 0.10 mg/L C - 0.20 mg/L	-	-	8PT & NS: 50 mg/L avg. day 1150 mg/L max. day 6.12
	pH	6.5 - 9.5	Marine: A - 6.5 - 8.5 B,C - 6.5 - 9.0 Fresh waters: A,B - 6.5 - 8.5 C - 6.5 - 9.0	5.5 - 9.5	-	-
	Nitrogen: Ammonia	35 mg/L Ammonia plants: Existing (600 imp gal/ton NH ₃): 0.210 lb/10 ³ avg day 0.420 " 1 day exceeding 0.630 lb/10 ³ lb max day New (270 imp gal/ton NH ₃): 0.105 lb/10 ³ lb avg day 0.210 " 1 day exceeding 0.315 lb/10 ³ lb max day	Marine & fresh waters: A - 10 mg/L (as N) B,C - 15 mg/L	10 mg/L (as N)	-	Ammonia production: BPT: 0.0625 lb/1,000 lb avg. day 0.1875 lb/1,000 lb max. day NS: 0.055 lb/10 ³ lb avg. day 0.11 lb/10 ³ lb max. day 6.12

Continued...

TABLE 6.4 EFFLUENT LIMITATIONS FOR SELECTED POLLUTANTS FROM SELECTED CHEMICAL INDUSTRIES - WATER (continued)

Industry	Parameter	Limitation in Given Jurisdiction				
		Alberta 1.5	B.C. 2.1	Ontario 3.3	Sask.	Can. Fed. 5.11
	Nitrate	20 mg/L	Marine & fresh waters: A - 10 mg/L B, C - 50 mg/L	-	-	-
	Organic	10 mg/L	Marine & fresh waters: A - 15 mg/L (kjeldahl) B, C - 25 mg/L (kjeldahl)	-	-	-
	Phosphate	5 mg/L	Fresh water: A - 1.0 mg/L B - 10 mg/L C - 30 mg/L	1 mg/L	-	-

U.S. Fed. 6.11, 6.12

Ammonium nitrate
production:
BPT:0.37 lb/10³ lb.

prod., avg. day

0.67 lb/10³ lb.

prod., max. day

BAT & NS:

0.07 lb/10³ lb.

prod., avg. day

0.12 lb/10³ lb

max. day

6.12

Urea production

(depending on process):

BPT:

0.33-0.80 lb/10³ lb,

avg. day

0.61-1.48 lb/10³ lb,

max. day

BAT & NS:

0.24-0.46 "

avg. day

0.45-0.86 "

max. day

6.12

BPT, BAT & NS:

Total P, as P:

35 mg/L avg day

105 mg/L max. day

6.12

Continued...

TABLE 6.4 EFFLUENT LIMITATIONS FOR SELECTED POLLUTANTS FROM SELECTED CHEMICAL INDUSTRIES - WATER (continued)

Industry	Parameter	Limitation in Given Jurisdiction					
		Alberta 1.5	B.C. 2.1	Ontario 3.3	Sask.	Can. Fed. 5.11	U.S. Fed. 6.11, 6.12
Metals:	Chromium	0.30 mg/L (hexavalent)	0.2 mg/L (total)	1.0 mg/L	-	-	-
	Lead	0.10 mg/L	0.2 mg/L	1.0 mg/L	-	-	-
	Mercury	0.0005 mg/L	Marine & fresh waters: A-0.002 mg/L B, C-0.050 mg/L	0.001 mg/L (essentially 0)	-	-	-
	Nickel	1.0 mg/L	0.2 mg/L	1.0 mg/L	-	-	-
	Zinc	1.0 mg/L	Marine: A, B - 0.2 mg/L C - 0.3 mg/L Fresh waters: A, B, C - 0.2 mg/L	1.0 mg/L	-	-	-
Toxicity	24-hr static LC ₅₀ ^a 50% effluent		96 hr LC ₅₀ ^a Marine: 50% A-50%; B-45%; C-25% Fresh water: A-100%; B-90%; C-50%	-	-	-	-

^aConcentration of effluent in which 50% of test organisms remain alive for a 96-hour period. Example: Marine waters, C level = 25%, i.e., in a solution composed of 25% effluent and 75% makeup water, 50% must remain alive for the 96 hr test period. For A level, the same must be achieved in a stronger mixture composed of 50% effluent.

industrial discharge standard applies, and closely approximates that of the U.S., the latter, for Best Practicable Technology (BPT), being about 0.001 mg/l if it is assumed that about 35,000 gallons of effluent are produced per ton of chlorine production. The figure for British Columbia is twice that, whereas the Canadian Federal figure is an entire order of magnitude higher, being equivalent to about 0.019 mg/l at 35,000 gal/ton. British Columbia's and Ontario's limitations for suspended solids are of similar magnitude, whereas that for the U.S. is considerably more stringent, amounting to approximately 2.4 mg/l at 35,000 gal/ton.

Fertilizer Industry

Processes and Pollutants. A fertilizer manufacturing complex can encompass a variety of chemical manufacturing processes, depending on the type of fertilizers being made. This discussion summarizes the chief processes required for the manufacture of nitrogen and phosphorus fertilizers, and the pollutants that originate from them.

Basic to the manufacture of nitrogen fertilizers is the synthesis of ammonia from nitrogen and hydrogen in a high-pressure catalytic process. The chief contaminant generated also is ammonia. The ammonia thus formed is an input to the manufacture of nitric acid, which is produced by the oxidation of the ammonia in the presence of a catalyst and solution of the nitrogen dioxide product in absorption towers. The chief airborne waste is oxides of nitrogen, which may be reduced catalytically. Ammonia is also combined with carbon dioxide to form ammonium carbonate, which is decomposed to yield urea. The urea is concentrated by evaporation and solidified in prilling towers. The principal contaminants are urea fume particulates in the airborne wastes and ammonia and organic nitrogen in the aqueous condensates. Finally, ammonium nitrate is formed by the neutralization reaction of ammonia and nitric acid, followed by evaporation and solidification of the product in prilling towers. The stream evolved in neutralization contains ammonia and ammonium nitrate, and this is condensed as waste streams. The airborne effluents of the prilling towers contain small particles of ammonium nitrate.

The basic raw material for phosphate fertilizers is phosphate-bearing rock. It first undergoes grinding, which gives rise to airborne fluorides. The ground rock is then reacted with sulphuric acid to produce soluble phosphates. Phosphates in liquid effluents originate in rock dust, surface runoff, and boiler blowdown. The manufacture of the sulphuric

acid reactant consists of the burning of sulphur, with the resulting sulphur dioxide being converted to the trioxide, which is then absorbed to form the acid. Sulphur dioxide, sulphur trioxide, and sulfuric acid mist are potential air pollutants originating in this process.

The Province of Alberta guidelines for this industry discuss control measures in some detail (1.4, 1.5).

Comparison of Standards. The limitations for pollutant discharges to the atmosphere are given in Table 6.3. Alberta, British Columbia, and the U.S. have requirements specifically for this industry. The Alberta design figures for sulphur dioxide, sulphur trioxide, and sulphuric acid mist, and oxides of nitrogen are identical to those of the U.S. In the case of sulphur dioxide, British Columbia's A-level requirements are slightly more stringent, and in the case of oxides of nitrogen, somewhat less stringent, than those of the other jurisdictions, whereas its B and C levels appear, in the latter case, much more lenient. Alberta and the U.S. have very similar requirements for emissions of fluorides, whereas those of British Columbia are not as stringent when converted to comparable units.

Table 6.4 gives the effluent limitations for waterborne effluents. The specific requirements given by Alberta, British Columbia, and the U.S. are tabulated, along with the general industrial figures for Ontario. The values for suspended solids are of a similar order of magnitude in all jurisdictions. For toxic substances, which are not specified by the U.S., the values given vary somewhat, with those of British Columbia and Alberta usually more stringent than those of Ontario. This observation includes chromium, which may be present in cooling tower blowdown. Alberta appears to have the least stringent requirements for ammonia. Alberta's limit for nitrate is between the A and B levels for British Columbia, but Alberta's limit for organic nitrogen is more stringent than British Columbia's A level. The U.S. figures for these parameters are on a production basis and are not directly comparable. Alberta's standard for phosphate appears less stringent than Ontario's and British Columbia's A level, but more stringent than British Columbia B and C levels. The toxicity parameters cannot be compared directly, because the type of test is different, but Alberta's requirements are not so strict as those of British Columbia, because, whereas the latter required 50% of the fish to survive in 50% effluent for 96 hours, the former requires only 24 hours survival.

Vinyl Chloride Industry

Because of the high toxicity of vinyl chloride, Alberta, the Canadian Federal government, and the U.S. government have set standards for airborne emissions from its manufacture. As Table 6.3 shows, these are substantially identical.

NATURAL GAS PROCESSING

Process and Pollutants. The processing of natural gas consists of the removal of hydrogen sulphide and heavy hydrocarbons from the sour gas. The hydrogen sulphide is stripped from the natural gas with an amine solution. It is then liberated and converted to elemental sulphur, usually by the Claus process, which consists of the reaction of hydrogen sulphide and sulphur dioxide to form sulphur and water. The efficiency of conversion of hydrogen sulphide to sulphur is the chief concern of limits on airborne emissions from this industry.

The inlet units separating water from the gas and the regeneration gas scrubbers produce oil-contaminated water, which can undergo skimming for oil removal. Suspended solids and organics with biochemical oxygen demand can be generated by boiler water treatment and blowdown and amine filter backwashing.

Comparison of Standards. As Table 6.5 shows, Alberta and British Columbia are the only study jurisdictions having sulphur recovery standards for natural gas processing plants. The standards depend, in the case of Alberta, on sulphur inlet rate and gas composition for new plants, whereas the requirements for existing plants are arrived at individually. In British Columbia, the requirements also depend on gas composition, and the new plants (A level) are required to meet standards in a very high range similar to Alberta's requirements. It should be remembered that, because the amounts of inlet sulphur are very large, a difference of a few percentage points in recovery efficiency makes a rather large difference in the actual weight of sulphur recovered.

Table 6.6 shows the effluent limitations for waterborne discharges. Alberta and British Columbia have specific standards for this industry, and the general industrial limits for Ontario are included for comparative purposes. British Columbia and Ontario limits for suspended solids are in the range that would be expected as a result of a well-operated secondary wastewater treatment plant, whereas Alberta's are

TABLE 6.5 EFFLUENT LIMITATIONS FOR NATURAL GAS PROCESSING PLANTS - AIR

Parameter	Limitation in Given Jurisdiction					
	Alta. 1.6	B.C. 2.1	Ont. 3.5	Sask.	Can. Fed.	U.S. Fed.
Sulphur recovery	$H_2S \geq 40\%$ New plants: 94.5% - sulphur in- let rate 10 tons/day 99% - sulphur in- let rate ≥ 2500 tons/day Existing plants: Per approvals	CO_2/H_2S ratio < 10 : A - 99% B - 95% C - 92%	-	-	-	-
	Ambient levels specified 1.7	CO_2/H_2S ratio > 10 : A - 95% B - 92% C - 85%	see Table 6.0	-	-	-
SO_2						

† Values determined from graph giving these as min. & max., as well as intermediate values.

* long tons

somewhat more lenient. Ammonia nitrogen levels are similar for all jurisdictions. For both sulphide and oil and grease, Alberta's levels are somewhat more lenient than British Columbia's A level. Figures for oxygen demand, Alberta's in terms of COD and British Columbia's in terms of BOD, are not directly comparable. Both jurisdictions give limits for a wide variety of metals. No special pattern emerges of one jurisdiction being consistently more restrictive than the other, although it may be remarked that Alberta's limit for mercury is especially strict, being at most five times greater than the ambient values listed for protection of aquatic life in several jurisdictions (Table 5.2). Likewise, Alberta's toxicity standard is somewhat more stringent than that of British Columbia for fresh water (A level).

PULP AND PAPER MILLS

This discussion is limited to mills using the sulphate or kraft process. Both mills in Alberta are of this type.

Process and Pollutants. The manufacture of kraft pulp includes the removal of bark from the wood, making of chips, digesting (cooking) of the chips with a mixture of chemicals to form the pulp, and subsequent washing of the pulp and screening to improve its quality. This may be followed by bleaching and/or the papermaking process. All of these steps generate potential water pollutants and the pulping operation creates several air pollutants of concern as well.

Hydraulic removal of bark from the pulp logs results in effluents high in suspended solids and biochemical oxygen demand. In the actual pulping process, the wood chips are digested for several hours with a mixture of sodium sulphide, hydroxide, sulphate, and carbonate. This dissolves the lignin and noncellulosic materials binding the wood fibers together. The spent cooking liquor then undergoes evaporation and incineration to recover the process chemicals. The remainder is dissolved in water and lime is added, forming a "white liquor", which is returned to the pulping operation, and a lime mud consisting mainly of calcium carbonate. The latter is calcined to recover lime, which can then be used to create more white liquor. The recovery furnace generates both particulate matter and sulphur-containing compounds in its airborne effluents, and the lime kiln is a further source of particulates. Washing, screening, bleaching, and papermaking processes generate further aqueous effluents containing solids and oxygen-demanding materials. In modern paper mills, recovery systems perform the dual purpose of saving the fibers and fillers and of reducing the pollution loads in the mill

TABLE 6.6 EFFLUENT LIMITATIONS FOR NATURAL GAS PROCESSING PLANTS - WATER

Parameter	Limitation in Given Jurisdiction					
	Alta. 1.8	B.C. 2.1	Ont. 3.3	Sask.	Can. Fed.	U.S. Fed.
Odour (TON)	100 units	-	-	-	-	-
Solids, total suspended	100 lb/bil ft ³ raw gas 50 mg/L	Marine & fresh waters: A,B-20 mg/L C-30 mg/L	15 ppm _w	-	-	-
Nitrogen, ammonia	50 lb/bil ft ³ raw gas 10 mg/L	A,B-10 mg/L C-15 mg/L	10 mg/L	-	-	-
pH	6.5 - 9.5	Marine: A-6.5-8.5 B,C-6.5-9.0 Fresh waters: A,B-6.5-8.5 C-6.5-9.0	5.5-9.5	-	-	-
Sulphide (total)	1 lb/bil ft ³ raw gas 0.2 mg/L	Marine & fresh waters: A,B-0.10 mg/L C-1.0 mg/L	-	-	-	-
Oil & grease	100 lb/bil ft ³ raw gas 10 mg/L	Marine: A-10 mg/L total oil B-10 mg/L non-volatile oil C-15 mg/L non-volatile oil Fresh water: A-5 mg/L total oil B-10 mg/L non-volatile oil C-15 mg/L non-volatile oil	15 ppm _w	-	-	-
Oxygen demand: Chemical	1,000 lb/bil ft ³ raw gas 500 mg/L	-	-	-	-	-
Biochemical 5,200	-	Marine & fresh waters: A-20 mg/L B-45 mg/L C-130 mg/L	15 mg/L	-	-	-
Metals: Arsenic	0.25 mg/L	Marine: A,B-0.05 mg/L C-0.08 mg/L Fresh water: A,B,C-0.05 mg/L	-	-	-	-

Continued

TABLE 8.8 EFFLUENT LIMITATIONS FOR NATURAL GAS PROCESSING PLANTS — WATER (continued)

Parameter	Limitation in Given Jurisdiction					
	Alta. 1.8	B.C. 2.1	Ont. 3.3	Sask.	Can. Fed.	U.S. Fed.
Barium	1.0 mg/L	Marine: A,B-1.0 mg/L C-1.5 mg/L Fresh water: A,B,C-1.0 mg/L	-	-	-	-
Cadmium	0.10 mg/L	-	0.001 mg/L (essentially 0)	-	-	-
Chromium	0.30 mg/L (hexavalent)	0.2 mg/L	1.0 mg/L	-	-	-
Copper	1.0 mg/L	0.1 mg/L	1.0 mg/L	-	-	-
Iron	1.0 mg/L	-	-	-	-	-
Lead	0.10 mg/L	0.2 mg/L	1.0 mg/L	-	-	-
Manganese	1.0 mg/L	-	-	-	-	-
Mercury	0.0005 mg/L	Marine & fresh waters: A- .002 mg/L B,C-0.050 mg/L	0.001 mg/L (essentially 0)	-	-	-
Nickel	1.0 mg/L	0.2 mg/L	1.0 mg/L	-	-	-
Selenium	1.0 mg/L	-	-	-	-	-
Silver	0.10 mg/L	-	-	-	-	-
Tin	-	-	1.0 mg/L	-	-	-
Vanadium	1.0 mg/L	-	-	-	-	-
Zinc	1.0 mg/L	Marine: A,B-0.2 mg/L C-0.3 mg/L Fresh water: A,B,C-0.2 mg/L	1.0 mg/L	-	-	-
Cyanide	0.025 mg/L	Marine & fresh waters: A,B-0.10 mg/L C-0.20 mg/L	-	-	-	-
Toxicity	LC ₂₀ 96-hr, 100% effluent; Aggregate of metals & cyanide ≤ 5 mg/L	LC ₅₀ 96-hr, % effluent: Marine: A-50; B-45; C-25 Fresh water: A-100; B- 90; C- 50;	-	-	-	-

effluents. The main types of recovery devices, often known as "save-alls", use filtration, sedimentation, and flotation processes. Further treatment of liquid wastes from the manufacturing complex is accomplished by sedimentation to remove suspended solids and stabilization in lagoons or ponds, or by other aerobic treatment processes.

Comparison of Standards

Airborne Emissions. Table 6.7 shows the limitations for airborne emissions from kraft mills in the study jurisdictions. British Columbia, the Canadian Federal, and the U.S. Federal government have promulgated limitations for airborne emissions from the pulp and paper industry applicable to kraft mills. Ontario has adopted the Canadian Federal limits. Alberta and Saskatchewan do not have specific standards for this industry. The chief parameters of concern are particulates and sulphur-containing compounds. For particulates from the recovery stages of the pulping process, the figures for British Columbia and the U.S. are in terms of concentration, whereas those of the Canadian Federal government are in terms of units of production, so a direct comparison is not possible. British Columbia's A-level figure is similar to Alberta's general particulate emission standard, and is slightly less stringent than the comparable U.S. standard. For the dissolving tank effluent, British Columbia's A-level standard and the Canadian Federal standard are very close, and again, are less stringent than the Ontario figure. Figures for particulates from power boiler emissions in the British Columbia and Canadian Federal limitations also are nearly identical. With respect to sulphur-bearing emissions, British Columbia's A-level limits are very close to those set forth by the U.S. and are identical with the Canadian Federal recommendations for the lime kiln and dissolving tank emissions.

Waterborne Emissions. Table 6.8 gives the effluent limitations for kraft mill wastewaters. As dictated by the nature of the wastes, the chief parameters of concern in all jurisdictions are suspended solids and biochemical oxygen demand. All jurisdictions having specific limitations for this industry (British Columbia, Canadian Federal adopted also by Ontario, and the U.S. Federal government), specify limits for various components of the total process. All have, as well, several levels of performance expectation. British Columbia's A level represents the goal for new discharges and discharges from altered facilities and a desirable goal for all discharges, whereas B level is intended as an interim goal for existing installations. The Canadian Federal limits likewise distinguish between new and altered mills and unaltered existing mills. U.S. Federal limits are for best available technology

TABLE 6.7 EFFLUENT LIMITATIONS FOR KRAFT PULP MILLS - AIR

Parameter	Limitation in Given Jurisdiction*					
	Alta. 1.1	B.C. 2.3	Ont. 5.6 (new plants)	Sask. 4.1	Can. Fed. 5.6 (new plants)	U.S. Fed. 6.2
Opacity: General	40% avg. for 6 consec. min	-	-	40%	-	-
Power boiler, oil	-	10% for 57 min in 60	20% assoc. w/	-	20% assoc. w/particulate	35% (recovery furnace)
Power boiler, combination fuel	-	20% for 27 min in 30 non-coastal	35% particulate limits	-	35% limits	-
Particulates: General	0.20 lb/1,000 lb effluent (≤ 0.11 gr/scf)	-	-	-	-	-
Recovery furnace	-	A-5.5 mg/mol (0.10 gr/dscf) B-11.0 (0.20)	2500g/ADUT (5.0 lb/ADT)	-	2500g/ADUT (5.0 lb/ADT)	0.10g/dscm (0.044 gr/dscf)
Lime kiln	-	A-5.5 B-11.0	500g/ADUT (1.0 lb/ADT)	-	500 g/ADUT (1.0 lb/ADT)	0.15g/dscm (0.067 gr/dscf)-0.30 depending on fuel
Dissolving tank	-	A-0.20 kg/ton (0.4 lb/ADUT) B-0.40 (0.80)	250g/ADUT (0.5 lb/ADT)	-	250 g/ADUT (0.5 lb/ADT)	0.1/kg black liquor solids (dry wt) (0.2 lb/ton)
Power boiler, oil only	-	A-3.9 mg/mol (0.07 gr/dscf) B-5.5 (0.10)	0.16 g/m ³ (0.07 gr/scf)	-	0.16g/m ³ (0.07 gr/scf)	-
Power boiler, combination fuel	-	A-5.5 mg/mol B-11.0	Coal: 0.23g/m ³ (0.10 gr/scf) Wood or combination: 0.34 g/m ³ (0.15 gr/scf)	-	Coal: 0.23 g/m ³ (0.10gr/scf) Wood or combination: 0.34 g/m ³ (0.15 gr/scf)	-

* scf = standard cubic feet

dscf = dry standard cubic feet

dscm = dry standard cubic meter

ADUT = air-dry unbleached ton (metric tonne for Can. Fed. and Ontario; short ton for B.C.)

ADT = air-dry ton (short)

gr = grains

g = grams

Continued...

TABLE 6.7 EFFLUENT LIMITATIONS FOR KRAFT PULP MILLS - AIR (continued)

Parameter	Limitation in Given Jurisdiction					
	Alta. 1.1	B.C. 2.3	Ont. 5.6 (new plants)	Sask. 4.1	Can. Fed. 5.6 (new plants)	U.S. Fed. 6.2
Sulphur, total reduced: Recovery furnace	-	A-0.2 mg/mol (6.5 ppm _v)(as H ₂ S) B-0.9 (26)	150/ADUT (0.3 lb/ADUT)	-	150 g/ADUT (0.3 lb/ADUT)	5 ppm _v dry basis, 840 ₂
Other process	-	A-0.225 kg/ton (0.45 lb/ADUT) B-0.350 (0.70) (as S)	15 g/ADUT- digester, evap. & stripper 225 g/ADUT- kiln dis. tank etc.	-	15 g/ADUT -digester, evap., & stripper 225 g/ADUT- kiln, dis. tank	5 ppm _v -digester, washer, evap. & stripper 0.0084 g/kg - dis. tank 8 ppm _v - lime kiln
Power boiler, oil	-	A-19.2 mg/mol (300 ppm _v) B-64 mg/mol (1000)	- -	- -	- -	- -

TABLE 6.8 EFFLUENT LIMITATIONS FOR KRAFT PULP MILLS - WATER

Parameter	Limitation in Given Jurisdiction						
	Alta.	B.C. 2,3	5,7	Ontario	Sask.	Can. Fed. 5,7	U.S. Fed. 6,3
Suspended solids, total: Pulping process	-	A - 10kg/ton(20 lb/ADT) B - 17.5 " (35 lb/ADT)	New mill: 5 lb/ton Existing mill: 7 lb/ton	15 mg/L= 3.75 lb/ADT Existing mill: #30,000 gal/ton	-	New mill: 5 lb/ton Existing mill: 7 lb/ton	BAT: 3.7 lb/ton (unbleached) BPT: 12.0 lb/ton (unbleached) 23.8-32.8 lb/ton (bleached)
Debarker (hydraulic) (wet drum process)	-	A - 0.24 kg/m ³ (1.5 lb/cumft) B - 0.64 kg/m ³ (4.0 lb/cumft)	5 lb/ton New or expanded: 8 lb/ton Existing mill: 10 lb/ton	- - - Ambient +11°C	-	5 lb/ton ^a New or expanded mill: 8 lb/ton Existing mill: 10 lb/ton	BPT: 5.7 lb/ton (fine bleached)
Temperature	-	A, B - 35°C	-	-	-	-	-
Oxygen, dissolved	-	A - $\geq$ 2.0 mg/L	-	-	-	-	-
pH	-	A + B - 6.5 - 8.0	-	5.5 - 9.5	-	-	6.0-9.0 (unbleached kraft)
BOD ₅ :							
Debarker	-	A-0.18 kg/m ³ (1.1 lb/cumft) B-0.64 kg/m ³ (4.0 lb/cumft) A-7.5kg/ton(15 lb/ADT)	-	-	-	-	BPT: 2.0-2.4 lb/ton(bleached)
Kraft process	-	B-30kg/ton(60 lb/ADT)	New or expanded mill: 33 lb/ADT Existing mill: 64 lb/ADT	15mg/L= 3.75 lb/ADT #30,000 gal/ton ^a	-	New or expanded mill: 33 lb/ADT Existing mill: 64 lb/ADT	BAT: 2.7 lb/ton(unbleached) BPT: 5.6 lb/ton(unbleached) 11.0-16.1/ton(bleached)
Toxicity	-	A - 100% eff.vol. for 96-hr. LC ₅₀ B-30% effl.vol. for 96-hr LC ₅₀	65% effluent vol. for 96-hr LC ₂₀	-	-	65% effluent vol. for 96-hr LC ₂₀	-

^a short ton

(BAT) and best practicable technology (BPT). For debarker effluents, the Canadian Federal - Ontario limit is very similar to that of the U.S. for suspended solids content. For suspended solids from the pulping process the Canadian Federal - Ontario limit is only slightly greater than the U.S. BAT standard for unbleached kraft, and all of these are very much less than British Columbia's limits, which are closer to the U.S.'s BPT standard for bleached kraft. Ontario's own general industrial standards of 15 mg/l may take precedence over the adopted Federal standard, depending on the water usage of the mill.

The situation with respect to biochemical oxygen demand is quite different. For kraft process effluents, British Columbia's A-level limit is most nearly comparable to the U.S. BPT limit for bleached kraft, both of these being far lower than the Canadian Federal limits, even for new mills. In this case it is quite clear that Ontario's own general industrial discharge standard of 15 mg/l would take precedence over the Federal limit. It appears, in summary, that, compared with other standards, the Canadian Federal limits are quite stringent with respect to suspended solids and quite lax with respect to BOD.

The Canadian Federal toxicity requirements are quite close to, though not directly equivalent to, British Columbia's A-level limitation.

MUNICIPAL WASTEWATER TREATMENT PLANTS

Pollutants and Treatment Processes. Municipal wastewater treatment plants receive and treat wastewaters from a wide variety of sources. These include households, commercial establishments, some industrial plants, and sometimes storm runoff if the sewer system is of the "combined" type. Some of the sources, particularly of the industrial type, may be subject to pretreatment requirements before discharge to the municipal sewer system is allowed. Because of the very wide variety of activities generating effluents, especially in large metropolitan areas, municipal wastewater may be expected to contain a very large number of chemical elements and compounds. However, because most of these are highly diluted by the large volumes of other wastes, they usually are not singled out for individual analysis unless there is reason to suspect specific problems. The chief parameters of concern are those dealing with overall effects regardless of causative compound, namely, suspended solids and biochemical oxygen demand. Public health considerations sometimes dictate limits

on coliform bacteria. Nitrogen and phosphorus may be a problem, as may oil and grease and toxic and hazardous substances.

Conventional wastewater treatment in sizeable communities in North America may be of the primary or secondary type. Primary treatment usually consists of screening and comminution to eliminate large solids, grit removal, and quiet settling for several hours in a clarification tank to remove a major portion of the suspended solids. The settled solids are drawn off as sludge for treatment and disposal while the clarified effluent may or may not be chlorinated to kill bacteria before discharge to the receiving waters. The reduction in oxygen demand in the primary process is incidental to the removal of the solids. Secondary treatment, however, is chiefly aimed at removal of oxygen-demanding materials. After clarification, as in primary treatment, the waste stream passes to aeration tanks, or in some cases to trickling filters, where oxygen has an opportunity to make contact with and oxidize the oxygen-demanding substances. The effluent then undergoes further clarification and may be disinfected before discharge. When it is desired to remove nitrogen and/or phosphorus to control eutrophication, additional physical-chemical processes or other control measures may be used.

Comparison of Standards. Table 6.9 gives the published effluent limitations for municipal wastewater treatment plants.

British Columbia, Saskatchewan, and the U.S. have standards that specifically relate to treatment of municipal wastewaters. Those published by British Columbia are the most detailed in respect of requirements to meet various discharge situations, and like those of Saskatchewan, cover a large number of parameters. The figures given for Ontario are for industrial waste discharges, but Ontario officials have stated that these BOD and suspended solid requirements are also applied to discharges from municipal treatment plants, and the values from the same source for certain other parameters are given here for comparative purposes. Neither Alberta nor the Canadian Federal government appears to have specific standards covering this type of discharge, although the Canadian Federal government has guidelines covering effluents of similar character from Federal establishments, which have been included in Table 6.9 for the purposes of comparison.

The text of British Columbia's municipal waste objectives report indicates that all new discharges are required to meet Level AA requirements, whereas existing discharges will be required to upgrade first to Level BB and then to Level AA. Both levels are stated to be requirements to be met at

TABLE 6.9 EFFLUENT LIMITATIONS FOR MUNICIPAL WASTEWATER TREATMENT PLANTS

Parameter	Effluent Limitation in Given Jurisdiction						
	Alta.	B.C. 2.5		Ont. 3.3	Sask. 4.2		Can. Fed. 5.14
		AM	B8		Secondary	Primary	
Biochemical oxygen demand (BOD ₅)	-	Streams, rivers, estuaries: 20:1 < D < 200:1 30 mg/L 200:1 < D < 2000:1 45 mg/L Lakes: 100 mg/L 30 mg/L Streams, rivers, estuaries: 20:1 < D < 200:1 40 mg/L 200:1 < D < 2000:1 60 mg/L Lakes: 100 mg/L 40 mg/L	15 mg/L	15-30 mg/L 85-95% removal	100-150 mg/L 25-45% removal	20 mg/L	30 mg/L monthly avg. (85% removal) 45 mg/L weekly avg.
Suspended solids	-	200:1 < D < 2000:1 130 mg/L D > 2000:1 130 mg/L Lakes: 30 mg/L 45 mg/L	15 mg/L	15-30 mg/L 85-95% removal	100-150 mg/L 35-65% removal	25 mg/L	30 mg/L monthly avg. (85% removal) 45 mg/L weekly avg.
Coliform organisms	-	Disinfection required	-	20,000-200,000/100mL 99.5-99.9% removal	25x10 ⁶ /100mL 40-60% removal	Fecal coliforms: 400/100 mL after disinfection	-
Nitrogen (ammonia)	-	-	10 mg/L (as N)	10-20 mg/L	-	-	-
pH	-	6.5-8.5	5.5-9.5	5.5-10.5	-	6-9	6.0 - 9.0
Phosphorus	-	1.5 mg/L (total P)	-	15-30 mg/L as P ₀₄	-	1.0 mg/L (total P) where removal required	-
Oil and grease	-	15 mg/L	15 mg/L	15-25 mg/L	-	15 mg/L	-
Phenolics	-	0.2 mg/L = 200 ppb	20 ppb	20-40 ppb	-	20 ppb	-

*For discharges to non-marine waters; average dry weather flows greater than 10,000 gal/day; objectives apply to all flows up to 3 times average dry weather flow. D=dilution.

†Objectives are for control of industrial waste discharges but apparently also are applied to discharges from municipal treatment plants.

These are guidelines applying only to domestic type effluents from Federal installations. They have no applicability to non-Federal municipal effluents.

all times. Thus the average concentrations would be expected to be below the stated concentrations. This would mean, in effect, that secondary treatment will be required eventually for streams, rivers, and estuaries where relatively low dilutions are available and for lakes, and that primary treatment will be the norm for situations where the largest dilutions are available.

Saskatchewan's published requirements give the expected effluent quality for primary and secondary treatment, but do not state under what circumstances each is required. This is evaluated on a case-by-case basis. However, primary treatment is a minimum requirement. The U.S. has required secondary treatment of all municipal discharges regardless of size or location, except in special circumstances. The figures in Table 6.9 state the required results of secondary treatment. It thus appears that secondary treatment is the norm in the jurisdictions studied, at least in more sensitive situations.

MUNICIPAL SOLID WASTE DISPOSAL

Disposal Methods. Municipal solid waste disposal encompasses the difficult problem of removing the enormous quantity of various materials generated by the normal activities of our society. The quantity is approximately 3 pounds per capita per day, consisting of paper, metal, plastics, organic matter, and numerous other materials. Added to the problem of ordinary wastes is that of hazardous wastes, which may include pathogenic wastes from hospitals and potentially pathogenic ones from international transportation facilities as well as toxic solids and liquids generated by industry.

In Canada, the two most frequently used means of municipal waste disposal are landfilling and incineration. Landfills usually provide the cheapest alternative, although their cost advantages are being re-examined as land costs in and near urban areas soar and the environmental hazards associated with landfills become more evident. Among the disadvantages of landfills are their consumption of land resources, generation of odor, attraction of birds, rats, and wildlife (including bears), problems caused by blowing away of light materials, fire hazards, and generation of leachate that may contaminate ground or surface waters.

Incineration has the advantages of more efficient use of urban land and the production of an inert residue of greatly reduced volume. Its chief disadvantages are its potential

for causing air pollution and its presently high cost. The latter may be diminished if the heat generated can be sold, but the usual practice in North America until now has been to incinerate with a large percentage of excess air and waste the heat generated.

Comparison of Standards

Tables 6.10 and 6.11 summarize selected standards for land disposal of municipal solid wastes in Alberta, British Columbia, Ontario, and Saskatchewan, for communities of more than 5,000 population and less than 5,000 population, respectively. Similar types of requirements may be found in most jurisdictions. All have some location restrictions, to protect either nearby land uses or the quality of surface and ground waters (British Columbia and Ontario). Fencing and attendance are required by most jurisdictions for the larger operations. Daily cover of the waste deposits is required in the larger communities, with British Columbia's requirements being the most stringent. Where depth of cover for cells and final cover are specified for the larger operations, (Alberta and Saskatchewan), they are 6 inches and 2 feet, respectively. These figures agree with the U.S. Federal requirements, which have not been tabulated here. Requirements concerning frequency of cover are less stringent the smaller the size of community served.

Table 6.12 compares requirements for airborne emissions from municipal waste incinerators. The Canadian Federal requirements, which apply only to "packaged" incinerators with capacities up to 900 kg/hr, are the most restrictive for opacity of stack effluents. The particulate emissions limitations for Alberta, British Columbia, and the U.S. are similar; the Canadian Federal requirement is given in terms of waste input. Both British Columbia and the Canadian Federal government also have standards for chlorides and sulphur dioxide. The sulphur dioxide limits are identical, while British Columbia's chloride limit is more stringent than that of the Federal government.

COAL-FIRED ELECTRIC GENERATING PLANTS

Process and Pollutants. The generation of electric power in coal-fired plants consists basically of the burning of coal to produce steam, which is then used to drive turbo-electric generators. The coal is first pulverized and then conducted to burners in a furnace. The steam is heated in tubes that line the furnace walls.

TABLE 8.10 REQUIREMENTS FOR DISPOSAL OF MUNICIPAL TYPE SOLID WASTES -LARGER LAND DISPOSAL OPERATIONS

Parameter	Alberta 1.-9	B.C. 2.-5	Ont. 3.-4	Sask. 6.-3
Facility designation	Sanitary landfill	Sanitary landfill, classes A & B	Landfilling site	Sanitary landfill
Population served	>5,000 mandatory	A- >10,000 B- 5,000-10,000	-	>5,000 mandatory
Location restrictions	>300 ft from cemeteries, >1,500 ft from hospitals, restaurants or other places of food preparation or storage, or dwellings	B- >10 road miles apart A,B - Not in free water; >4 ft. above normal highest groundwater level	"reasonable" distance from cemeteries "sufficiently" above max. groundwater table to prevent impairment	>300 ft from cemeteries >1500 ft from place of food preparation, serving, or storage, dwelling, school, or other educational institution
Resource recovery	Salvaging allowed if controlled	-	Scavenging not permitted	-
Fencing of site	Required	May be required to prevent nuisances and hazards	Required	Required
Attendance	-	If burning of non-putrescible wastes or disposal of hazardous wastes is carried on.	Continuous during site operation	Continuous at unloading area.
Burning	Not permitted	Non-putrescible wastes, under certain conditions, in site separate from landfill cells.	-	Not permitted
Frequency of cover	Population >20,000-daily <20,000- 3 times/week	Population >10,000-daily " 5,000-10,000 - 3 times/week or every 2nd day	"Regular"	Population >20,000 - daily " <20,000 - 3 times/week
Depth of cover: Cells	Not specified	6 in. (may include some hog fuel)	Not specified	6 in.
Top cell		2 ft (no hog fuel permitted)		2 ft.

TABLE 9.11 REQUIREMENTS FOR DISPOSAL OF MUNICIPAL-TYPE SOLID WASTES - SMALLER DISPOSAL OPERATIONS

Parameter	Alberta 1.8	British Columbia 2.5	Ontario 3.4	Saskatchewan 4.3
Facility designation	Modified landfill	Sanitary landfill, classes C, D, E	Dump	Modified landfill
Population served	<5,000 only	C-1,500-5,000 D- 500-1,500 E- 500	Restricted not by population but to specific geographical areas.	<5,000 only
Location restrictions	>300 ft from cemeteries >1500 ft from hospitals, restaurants or other places of food preparation or storage, or dwellings.	>10 road miles apart Not in free water >4 ft above normal highest ground water table	Not subject to flooding or draining directly to a watercourse >1/4 mile from nearest dwelling >200 yd from nearest public road >100 ft from watercourse, lake, pond. Not on land covered by water Scavenging not permitted	>300 ft from cemeteries >1500 ft from place of food preparation, serving, or storage, dwelling, school, or other educational institutions.
Resource recovery	Salvaging allowed if controlled	-	-	-
Fencing of site	Required	May be required to prevent nuisances and hazards	-	Required
Attendance	-	If burning of non-putrescible wastes is carried on.	-	-
Burning	Not permitted	Non-putrescible wastes, under certain conditions, in site separate from landfill cells	-	Not permitted
Frequency of cover	At least every 3 months, except in winter	C-once/week D-once/month or once/20 days E-once/2 months or 40 days	"As...necessary to prevent harm or material discomfort to any person."	Once/month, 1 May - 31 Oct.
Depth of cover: Cells	-	6 in. (may include some hog fuel)	"As...necessary to prevent harm or material discomfort to any person."	6 in.
Top cell	2 ft., seeded to grass	2 ft. (no hog fuel permitted)	-	2 ft.

TABLE 0.12 REQUIREMENTS FOR DISPOSAL OF MUNICIPAL TYPE SOLID WASTES - INCINERATION

Parameter	Limitation in Given Jurisdiction					
	Alta.	B.C.	Ont.	Sask.	Can. Fed.	U.S. Fed.
Bingleman No. or other visual indicator	-	§ 1, w/ variance to 2 allowed for 5% of operating time	Not darker than No. 1 on Visible Emission Chart of Province of Ontario, except 2 for 4 min/30 min.	§ 2	-	-
Opacity	40% avg. 6 consec. min.	§ 20% ^{2.5}	§ 20%; may be 40% for 4 min./30 min.	§ 40%	0% (new) ≤ 20% (existing)	-
Particulates	0.20 lb/1,000 lb effluent for capacity > 500 lb/hr (≠ 0.11 gr/scf)	0.100 gr/scf (12% CO ₂) 2.5	see Table 6.0	To meet ambient stds.	0.75g /kg solid waste (new)	0.08 gr/dscf (12%CO ₂)
Chlorides	-	50 ppm ^{2.1*}	see Table 6.0	-	100 ppm HCl, dry basis (50% excess air) (new)	-
SO ₂	-	250 ppm ^{2.4*}	see Table 6.0	-	250 ppm, dry basis (50% excess air) (new)	-

* According to Ref. 2.5, to meet most stringent industrial standards.

The airborne emissions from this process contain particulates, sulphur dioxide, and oxides of nitrogen. The particulates can be controlled very efficiently by electrostatic precipitators, occasionally preceded by cyclones. Oxides of nitrogen form at high combustion temperatures and are best controlled by design of the combustion process to favour their production as little as is practicable. Control of sulphur dioxide can be achieved by using low-sulphur coal (although the demand for this now exceeds the supply because of widespread tightening of air pollution control regulations), or by its removal from the flue gases. Wet or dry limestone processes are most commonly used for this purpose. They involve the reaction of the sulphur dioxide with calcium to form calcium sulphite or sulphate.

Comparison of Standards. Table 6.13 gives the airborne emission limits for this industry. Alberta includes a standard for particulates from power generation in its Clean Air (Maximum Levels) Regulations. British Columbia's may be found under the more general category of "industrial combustion". The Canadian and U.S. Federal governments have specific standards pertaining to coal-fired power plants.

For particulates, the limits set by Alberta and British Columbia (A) are very close, but these allow about twice the emission rate set by the Canadian Federal government for new plants and the U.S. standard for plants built in the early and mid-1970s. The standard for U.S. plants built since 1978 is far more stringent, being only 1/3 of the Canadian Federal limit.

The Canadian Federal and U.S. limits for oxides of nitrogen are nearly equivalent, whereas that for British Columbia is slightly more lenient at the A level and a great deal more so at the B and C levels.

The Canadian Federal standards for sulphur dioxide are somewhat more stringent than British Columbia's A level. The U.S. standards are based, for plants built since 1978, on percentage removals, with an absolute upper limit. While the U.S. upper limit is apparently twice the Canadian Federal standard, the percentage restrictions are likely to yield control results closer to those required by Canada. None of the Canadian jurisdictions studied appeared to have standards or guidelines for water-related practices in power stations. However, it is reported that such recommendations for new or expanded power stations are being prepared by a federal-provincial-industry task force.

TABLE 6.13 EMISSION LIMITATIONS FOR COAL-FIRED ELECTRIC POWER PLANTS

Parameter	Limitation in Given Jurisdiction					
	Alta. 1.1	B.C. 2.2*	Ont. 3.5	Sask. 4.1	Can.Fed. 5.13	U.S. Fed. 6.14
Opacity	<40% avg. over 6 consecutive minutes	-	< 20%, but may increase to 40% for ≤4 min/30 min. see Table 6.0	<40%	<20%, but may increase to 40% for ≤6 min/60 min.	<20% but may increase to 27% for 6 min/60 min.
Particulates	0.20 lb/1,000 lb effluent adj. to 50% excess air (≅ 5.4 lb/ton coal ≅ 0.194 lb/10 ⁶ BTU)	A-5.0 lb/ton coal (0.18 lb/10 ⁶ BTU) B-7.0 lb/ton coal (0.25 lb/10 ⁶ BTU) C-13 lb/ton coal (0.47 lb/10 ⁶ BTU)	see Table 6.0	-	0.1 lb/10 ⁶ BTU heat input	Built 1971-78: 0.1 lb/10 ⁶ BTU heat input Built after 1978: 0.03 lb/10 ⁶ BTU or 1% of potential combustion conc.
Nitrogen oxides as NO ₂	-	A-27 lb/ton coal (0.98 lb/10 ⁶ BTU) B-45 lb/ton coal (1.63 lb/10 ⁶ BTU) C-54 lb/ton coal (1.96 lb/10 ⁶ BTU)	see Table 6.0	-	0.6 lb/10 ⁶ BTU heat input	Built 1981-78: 0.7 lb/10 ⁶ BTU heat input Built after 1978: 0.5 lb/10 ⁶ BTU
Sulphur dioxide	-	A-20 lb/ton coal (0.72 lb/10 ⁶ BTU) B-30 lb/ton coal (1.09 lb/10 ⁶ BTU) C-60 lb/ton coal (2.17 lb/10 ⁶ BTU)	see Table 6.0	-	Units emitting 0.6-6.0 lb/10 ⁶ BTU: Control to 0.6 lb/10 ⁶ BTU Units emitting >6.0 lb/10 ⁶ BTU: 90% reduction	Built 1971-78: 1.2 lb/10 ⁶ BTU heat input Built after 1978: 1.2 lb/10 ⁶ BTU upper limit 10% of potential combustion conc. or 30% of potential combustion concentration if ≪0.6 lb/10 ⁶ BTU

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ABBREVIATIONS USED IN TABLES

ABS	— alkylbenzene sulfonate
ADT	— air dry ton (short)
ADUT	— air dry unbleached tonne
APHA	— American Public Health Association
BAT	— best available technology
bbl	— barrels
bil ft ³	— billion cubic feet
BPT	— best practical technology
BTU	— British Thermal Unit
cm	— centimetre
D	— dilution
dscf	— dry standard cubic feet
dscm	— dry standard cubic metre
g	— gram
gpm	— gallons per minute
gr	— grains
hr	— hour
ICRP	— International Commission on Radiological Protection
Imp gal	— Imperial gallon
JTU	— Jackson Turbidity Unit. See Table 5.2, page 119
kg	— kilogram
L	— litre
lb	— pound
LC ₅₀	— lethal concentration for 50% of test organisms under specified conditions. See Table 5.2, page 121
m	— metre
MBAS	— Methylene blue active substances. See Table 5.2, page 129
MBPD	— 1000 barrels per day
mg	— milligram
μg	— microgram
mi	— mile
mL	— millilitre
mo	— month
mol	— mole (unit amount of substance)
NS	—
pCi	— picoCuries
ppb	— parts per billion
ppm	— parts per million
Pt-Co unit	— platinum-cobalt unit. See Table 5.2, page 118
scf	— standard cubic feet
TL _m	— median tolerance limit. See Table 5.2, page 127
TON	— threshold odor number

SOURCES/ALBERTA (1.0)

- 1.1 Clean Air (Maximum Levels) Regulations; Alta. Reg. 218/75, as am. by Alta. Reg. 224/77, 334/77, 167/78, and 319/79.
- 1.2 Surface Water Quality Objectives. Alberta. Water Quality Branch, Standards and Approvals Div., Jan. 1977.
- 1.3 Waste Water Effluent Guidelines for Alberta Petroleum Refineries. Water Quality Branch, EPS, Aug. 16, 1976.
- 1.4 Guidelines for Limiting Contaminant Emissions to the Atmosphere from Fertilizer Plants and Related Industries in Alberta. Standards and Approvals Division, February 1976.
- 1.5 Waste Water Effluent Guidelines for Alberta Fertilizer Plants. Water Quality Branch, Standards and Approvals Division, Environmental Protection Service, October 13, 1976.
- 1.6 Sulphur Recovery Guidelines, Gas Processing Operations. Energy Resources Conservation Board and Alberta Environment, Informational letter IL 80-24, November 4, 1980.
- 1.7 Sulphur Recovery and Sulphur Dioxide Emissions at Gas Processing Plants Guidelines. IL-OG - 74-75, March 20, 1974.
- 1.8 Gas Processing Plants, Waste Water Management Standards. Standards and Approvals Division, Alberta Environment, September 1973.
- 1.9 Provincial Board of Health Regulations Respecting the Control of Refuse Disposal Systems. Alta. Reg. 273/71 as amended by Alta. Reg. 4/72.

SOURCES/BRITISH COLUMBIA (2.0)

- 2.1 Pollution Control Objectives for the Chemical and Petroleum Industries of British Columbia (1980).
- 2.2 Pollution Control Objectives. Food-Processing, Agriculturally Oriented, and Other Miscellaneous Industries of British Columbia (1980)
- 2.3 Pollution Control Objectives for the Forest Products Industry of British Columbia (1977)
- 2.4 Pollution Control Objectives for the Mining, Smelting and Related Industries of British Columbia (1979)
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- 2.6 Recommended Water Quality Standards. Health Branch, Dept. of Health Services and Hospital Insurance, B.C. (1969).

Tables I - VI

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- 3.1 Ambient Air Quality Criteria Regulation, O.Reg. 872/74, as amended by O.Reg. 158/75
- 3.2 Water Management - Goals, Objectives, Policies and Implementation Procedures of the Ministry of the Environment (1978)
- 3.3 Objectives for the Control of Industrial Waste Discharges in Ontario. Ministry of the Environment.
- 3.4 Environmental Protection (General) Regulation R.R.O. 1970, Reg. 824.
- 3.5 Air Pollution Control (General) Regulations. R.R.O. 1970, Reg. 15, as amended by O. Reg. 873/74 and O. Reg. 271/77.

SOURCES/SASKATCHEWAN (4.0)

- 4.1 Air Pollution Control Regulations. Sask. Reg. 211/75
- 4.2 Water Quality Objectives. Saskatchewan. Department of the Environment, Water Pollution Control Branch, Feb. 1977.
- 4.3 Waste Management Regulations. Sask. Reg. 198/72 as amended by Sask. Regs. 282/73, 43/74, and 18/75.

SOURCES/CANADA FEDERAL (5.0)

- 5.1 Ambient Air Quality Objectives; S O R /74-325.
- 5.2 Ambient Air Quality Objectives No. 2; S O R /75-32.
- 5.3 Ambient Air Quality Objectives, No. 3; S O R /78-74, as am. by 78/812.
- 5.4 Canadian Recommended Surface Water Quality Objectives. Environment Canada 1979.
- 5.5 Guidelines for Water Quality Objectives and Standards. D. of E., Inland Waters Directorate, Ottawa, Tech.Bull. 67(1972).
- 5.6 Wood Pulping Industry National Emission Guidelines for New Stationary Sources.
- 5.7 Pulp and Paper Effluent Regulations. Rept. No. EPSI-WP-72-1, Water Pollution Control Directorate, November 1971.
- 5.8 Petroleum Refinery Effluent Regulations and Guidelines. Rept. EPS 1-WP-74-1, Water Pollution Control Directorate, Jan. 1974.
- 5.9 Chlor-Alkali Mercury National Emission Standards Regulation. SOR/77-548. 6 July, 1977.
- 5.10 Vinyl Chloride National Emission Standards Regulations. SOR/79-299, 30 March, 1979.
- 5.11 Chlor-Alkali Mercury Liquid Effluent Regulations. Rept. EPS 1-WP-77-3, Sept. 1977.
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- 6.1 Quality Criteria for Water. Environmental Protection Agency, Washington, D.C. 1976.
- 6.2 Standards of Performance for Kraft Pulp Mills. 40 CFR 60.280-285. (air)
- 6.3 Pulp, Paper, and Paperboard Point Source Category. 40 CFR 430 (water)
- 6.4 Standards of Performance for Petroleum Refineries. 40 CFR 60.100-106 (air)
- 6.5 Petroleum Refinery Point Source Category, Integrated Subcategory. 40 CFR 419.50-56.
- 6.6 National Emission Standard for Mercury. 40 CFR 61.50-55.
- 6.7 Standards of Performance for Sulfuric Acid Plants. 40 CFR 60.80-85.
- 6.8 Standards of Performance for Nitric Acid Plants. 40 CFR 60.70-74.
- 6.9 Standards of Performance for the Phosphate Fertilizer Industry. 40 CFR 60.200-244.
- 6.10 National Emission Standard for Vinyl Chloride. 40 CFR 61.60-71.
- 6.11 Chlorine and Sodium or Potassium Hydroxide Production Subcategory. 40 CFR 415.60-66.
- 6.12 Fertilizer Manufacturing Point Source Category. 40 CFR 418.
- 6.13 Standards of Performance for Incinerators. 40 CFR 60.50-54.
- 6.14 Standards of Performance for Fossil-Fuel-Fired Steam Generators for Which Construction Is Commenced After August 17, 1971, and Standards of Performance for Electric Utility Steam Generation Units for Which Constructions Is Commenced After September 18, 1978. 40 CFR 60.40-49a.
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CHAPTER 7

ENFORCEMENT OF ENVIRONMENTAL STANDARDS

Environmental standards are nearly useless if there are no effective mechanisms for assuring compliance. All jurisdictions studied have given attention to enforcement of their standards. However there is little critical analysis of enforcement programs and techniques. This situation is not unique to environmental law. The Law Reform Commission of Canada has noted, in a recent working paper on administrative sanctions, that sanctions are not well understood or studied anywhere(1). There seems to be a regrettable tendency on the part of law makers, the public, and commentators to assume that laws enforce themselves. They usually do not.

This study was not directed primarily at enforcement. Thus, it will not be possible to provide a comprehensive view of enforcement strategies and practices. However, during our research we became aware of a number of issues bearing on enforcement and enforcement policy. We shall review these issues in this chapter.

LACK OF COMPLIANCE STATISTICS

Not only is it difficult to find reliable information concerning enforcement strategies and techniques, it is also difficult to determine how well environmental standards are being complied with. Ambient conditions are monitored by a variety of agencies, and the results are often published. But these reports do not indicate whether individual companies are complying with their emission and effluent standards. Often dischargers are required to monitor their effluents and emissions. These data are reported to government agencies, but formal publication of the data, or of summaries of the data, is rare.

In British Columbia, for example, monitoring data are recorded in a computerized data base. Access can apparently be arranged for study purposes, but information concerning the degree of compliance with permits in British Columbia does not appear to exist in published form.

Alberta Department of the Environment policy is to make ambient and emission data resulting from industry monitoring required by operating licences available for review by the public and

the media(2). Similarly Ontario Environment makes industry monitoring data available for review by the public at local Ministry offices(3). Company status reports on compliance with orders or program approvals are also available for public review. However, proprietary information in status reports that is identified by the company and agreed to by the Ministry will be excluded. In both cases, the basic difficulties are that the public is not sufficiently aware of the availability of these data, and that there are no summaries or overview documents to identify problems and reveal general issues and trends.

The federal Water Pollution Control Directorate regularly publishes information concerning compliance with the environmental standards that it enforces. These include status reports on compliance under the Chlor-Alkali Mercury Liquid Effluent Regulations(4), the Pulp and Paper Effluent Regulations(5), and the Petroleum Refinery Effluent Regulations(6). These reports are technical and do not appear to give much insight into the enforcement process or to the state of the environment.

Several exceptions to this general lack of enforcement analysis should be noted. The first is a study conducted in British Columbia by a temporary government agency known as the Fraser River Task Force(7). In 1980, the Government of British Columbia created a task force consisting of four conservation officers and three waste management technicians. Their assignment was to investigate all illegal sources of pollution in the lower Fraser River. Between February and July, 1980, the team members completed 40 investigations. They discovered what they described as "many chronic problems involving illegal discharges of effluents, dumping of solid materials and violation of Pollution Control Permits or the conditions of these Permits." At the end of its study, the Task Force recommended that charges be laid against 19 dischargers. Decisions were pending with respect to three others. In other words, in approximately half of the cases investigated the task force identified either illegal discharges (discharges that were not under permit) or non-compliance with permit standards or conditions.

The report also outlined some of the difficulties that can arise with respect to enforcement of environmental legislation. For example, while the Pollution Control Act gives "officers" adequate powers of inspection, only the regional managers and assistant regional managers were officially designated as officers under the Act. Conservation officers, who usually carried out enforcement duties, were not. A second problem involved the permits themselves. These often contained terms

and conditions that were too vague to be enforceable. This problem is discussed later in this chapter.

A third problem is indicated by the following quotation from the report:

We experienced some difficulty with the Environmental Labs which we strongly suspect is caused by a lack of sufficient numbers of legal scientists. The Labs constantly wanted us to predict the numbers of samples we would be submitting for a given time period and they appeared to have difficulty understanding that enforcement problems, especially violations, cannot be predicted on a day to day basis, let alone a week to week basis.

Obviously violators won't wait until the labs are ready for them. It may not be so obvious that time really is critical in enforcement. Most environmental statutes specify limitation periods, within which time any prosecution must be started. These are typically short. If long delays are encountered in processing samples it may be impossible to lay the charge because the limitation period has passed. The point the Task Force was making, of course, is that there must be adequate laboratory facilities and staff to handle enforcement samples on a priority basis.

We do not intend to single out the British Columbia government by relating this study. In fact, it is to the credit of that government that the task force investigation was undertaken. Rather, the point to be made from this study is that the existence of permits and environmental standards by no means guarantees compliance with these standards. Furthermore, a serious lack of information on compliance seems to exist. The British Columbia study is noteworthy because it is so rare. For that reason, we will be referring to it often during this discussion of enforcement.

Laymen, and knowledgeable professionals from other fields, must find it difficult to inform themselves with respect to the state of the environment in Canada. They will encounter highly critical reports issued by environmental organizations and the press. These often suggest that environmental standards are not being enforced. They may also find government reports presenting highly technical ambient monitoring data. If they read carefully, they may also find some articles describing some successful abatement actions that have been undertaken

either by government or industry. But they will probably not find any authoritative statements evaluating the degree of compliance that is being achieved.

A model was identified that suggests how this information gap may be remedied. The Annual Reviews(8) published by the Canadian Environmental Advisory Council provide an overview of information available concerning selected environmental problems in Canada, as well as the regulatory controls in place. While these reports do not present any concrete information with respect to the enforcement of environmental standards, this kind of report could be used to inform interested members of the public about the true state of the Canadian environment and our attempts to set and achieve appropriate environmental standards. There should be a source of information on this issue that people could respect and trust; and there isn't.

MONITORING DISCHARGES

Monitoring of discharges is an essential ingredient of any enforcement strategy. This seems to be well recognized by regulatory officials in all jurisdictions, since some form of regulatory monitoring is required by each jurisdiction. In all study jurisdictions it is standard practice to require the discharger to monitor its effluents and emissions. Virtually all of the permits examined included a monitoring requirement of some sort. Usually the data required, the frequency of monitoring, and the method of analysis were specified. Alberta publishes comprehensive Air Monitoring Directives for major industries. These are incorporated by reference into operating licences. Recent amendments to The Clean Air Act(9) and The Clean Water Act(10) clarify the authority of the Director to specify monitoring requirements as conditions of licences and as terms of emission control orders. The various Federal Fisheries Act regulations and guidelines and emission guidelines under the Clean Air Act contain reporting and testing details. In addition to this industry monitoring, each jurisdiction has some system for checking the validity of the monitoring data.

It is important that monitoring conditions in permits or licences not be too vague to be meaningful. For example, one British Columbia condition merely stated: "Monitoring will be required as specified by the Director from time to time." This sort of condition amounts to little more than notice to the company that it may be required to do something at some time in the future. It is not clear why a condition

of this sort would be included since it would have no enforcement value.

Other examples include an Ontario Certificate of Approval condition that stated:

"Total reduced sulphur emissions from all three oxidation unit stacks shall be determined by the Company by source testing under supervision of the Air Resources Branch, within six months after start-up of the oxidation units"

and a Saskatchewan condition that "all monitoring equipment must meet minimum standards acceptable to the Director". Alberta monitoring requirements are by far the most detailed and specific that were reviewed. However even Alberta licences contained conditions such as a requirement that sampling stations to determine ambient levels of suspended particulates "shall be maintained at suitable locations in the vicinity of the plant and operated at a frequency satisfactory to the Director of Standards and Approvals."

Monitoring requirements of this type are likely not to be enforceable. They may be adequate so long as no disputes arise. But authority to impose disputed requirements is the very essence of enforcement.

Another difficulty that can arise with respect to monitoring data is illustrated by a 1977 case, R v Great Canadian Oil Sands(11). The Company in that case was charged with emitting sulphur dioxide in excess of its licence. The prosecution tried to rely on monitoring data in that case, but because continuous monitoring equipment was not used it was necessary to calculate a half-hour average concentration mathematically from readings taken every 12 minutes. Mathematical calculation of the half-hour average level, to which the licence standard was related, was seen by the court as pure speculation that could not form the basis of a criminal conviction.

The case illustrates a number of difficulties in enforcement. First, there is the obvious point about monitoring. It should be very carefully keyed to the environmental standards. The problem in the case was that the standards were expressed in one way, but a different measurement was required in the monitoring program. The second point may be a little less obvious, but the case does seem to point up difficulties

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inherent in relying on criminal prosecution as a means of enforcing environmental standards. It raises a basic question: does the burden of proving an offense beyond a reasonable doubt have any place in the attempt to secure compliance with licence terms and conditions? Should it matter that complete certainty in monitoring can not be obtained?

A final point that may be suggested is that perhaps judges and prosecutors are not familiar enough with the problems of environmental control. If the judge were more familiar with environmental monitoring might he have been more inclined to accept the mathematical averaging? Could additional evidence have convinced him on the point? Of course we cannot answer these questions in this study, but the issue must be considered. Experience in Ontario and British Columbia suggests the need for special training of prosecutors and enforcement officials. It also indicates that a lack of understanding on the part of the judiciary does make prosecutions difficult.

ENFORCEMENT ISSUES

Enforceability of Permits or Orders

Non-enforceability of orders and of conditions in permits and licences has clearly been a problem in some cases. One case was described above where the conditions were expressed in terms different from those required by the monitoring program. Other difficulties arise when the conditions are vague or ambiguous. This has been discussed in relation to monitoring. The British Columbia Fraser River Task Force found that "many of the Pollution Control Permits [that they studied] were written in vague or ambiguous terms and lacking in specific information" (7). They noted that this often made enforcement difficult.

The Task Force was particularly critical of the use of the phrase "at the Direction of the Regional Manager". It felt that more specific directions should be included in the permit. As the report pointed out, the discharger is free to operate as it will until it receives such directions. It is too easy in such a case for the pressures of time to intervene, and all too often directions may never be given. A similar comment may be made about the phrase "approved in writing by the Director" that appeared without accompanying time limits in several clauses of a Saskatchewan permit. We also encountered examples of vague terms or conditions in British Columbia permits. It may be useful to consider some examples briefly:

Pilot testing of chemical and biological and other secondary treatment alternatives ... is to be undertaken to determine the most cost-effective alternatives for the plant.

One may easily think of a host of questions about this clause. How many alternatives are to be tested? How much testing is to take place? What is meant by cost-effective? Obviously a court would have great difficulty in enforcing this provision. Consider a second example:

Should objectionable amounts of foam ... [result], additional treatment to reduce foam producing agents ... will be required.

What would constitute an objectionable amount of foam? What additional treatment would be required? Conditions of this kind were encountered in many of the permits we examined. However, it should be noted that they may have been more frequent in the older permits. Certainly government personnel were aware of the problem and asserted that greater care is now being taken. It should also be remembered that experience in this field really only dates from the early 1970s; some of the vague conditions undoubtedly resulted from inexperience.

In addition, there may be good reasons for including conditions that are not enforceable. For example, there may be some value to stating in the permit that additional treatment may be required if colour or foaming become objectionable. It is true that such a condition is unenforceable, but it does put the operator on notice of government concerns. If, in the future, government officials seek to amend the permit to deal with these concerns at least the operator can not say that it comes as a surprise. Thus an Ontario Certificate of Approval contained a condition that "if at some future date a standard for vinyl chloride that is more stringent than the present [not directly enforceable] guideline is enacted, the applicant will take the necessary steps to comply with that standard". Strictly speaking the condition is unnecessary because such a standard when added to Regulation 15 would be directly enforceable. However, the condition serves a valuable notice function and removes the basis for complaints about preemptory rule changes.

Negotiability of Enforcement

Thompson has shown in recent studies that negotiation occurs between dischargers and government at all stages of the standard setting and enforcement process(12). This is confirmed by the interviews we conducted in the study jurisdictions. Thompson attributes this chiefly to uncertainties about the causes and effects of pollution, the means of abating it, and societal value preferences. Where any one of these factors is uncertain there is a strong pressure on government officials to negotiate rather than take a hard line. The question is often, "How much can we get dischargers to clean up?" rather than, "Can we prosecute and obtain a conviction?"

Moreover, because many socially valuable activities also cause pollution, important value judgments have to be made. It would be ideal if all value judgments were made when standards are initially set, but that is a counsel of perfection. We are not proficient enough at either analysis or prediction to be able to foresee all the consequences of the standards that are set. And as Thompson points out, we probably do not have enough information in any event.

Some commentators are critical of this negotiating process. Rankin and Finkle recommend that environmental standards be enforced as a matter of course(13). They acknowledge that negotiation must take place but assert that it should be limited to the definition of standards. Once standards are established, Rankin and Finkle argue, they should be enforced rigorously. Otherwise, the law will lack certainty and dischargers will never take environmental standards seriously. Rankin and Finkle also point out that the public, outside of government, does not participate in this negotiation process. Even if they did have the right to participate they would not be able to command the resources that dischargers are able to commit. As a result, the negotiating process is seen as being biased toward industry.

Officials in the study jurisdictions disagree. In British Columbia, for example, a policy of negotiating with, rather than prosecuting, polluters has been favored for many years. It was felt that the cooperation of industry was essential to making progress in pollution control. It is easy to sympathize. Government needs information about industry's plans, the newest treatment techniques, and any spills that may occur. While polluters could be compelled to provide all of this information, it is likely that procedures would be cumbersome, time-consuming, and costly(14). Moreover, isn't it reasonable to assume that treatment facilities will work

better if management regards them as an integral part of the plant rather than a nuisance attached by governmental order?

Recently British Columbia has placed more emphasis on formal enforcement. In response to the Fraser River Task Force's report, an enforcement team has been created in the Lower Mainland area. The team consists of two conservation officers, two technicians, and a coordinator trained in police work. Also, 107 conservation officers in the province are being trained to enforce all of the province's environmental legislation. The province now seems intent on establishing that it means to enforce environmental standards, but it believes that there must still be room for negotiation. Environment officials point out that situations often arise where more can be accomplished through negotiation than can be accomplished by prosecuting.

Ontario has also established a special Investigations Unit that consists of a small select group of environmentally trained persons who have also received police training. Authority to lay charges for provincial offences has been delegated down to field level. New legislation is apparently being drafted to bring a number of offences under the Ontario Provincial Offences Act with authority in the special investigators to issue tickets.

Our view is that both negotiation and prosecution have a role to play in compliance policy. Basically this view is shared by environmental officials interviewed. One can easily think of examples where it would be wrong to negotiate. For example, consider the company that knowingly dumps toxic materials into the watercourses in the dead of night, in order to avoid controls. Or consider the company that breaks one promise after another and keeps the "negotiations" going for years. There must be an end to negotiations. The criminal process is a useful way of dealing with those who ignore the law or negotiate in bad faith.

On the other hand, one can just as easily think of situations where it would be silly to prosecute. Consider a firm that is subject to standards that were set on the assumption that a particular technology would be effective in controlling its emissions. What should happen if the technology does not work? Surely, the most sensible thing to do is for government and the firm to sit down and work out a new program for dealing with the problem. It is tempting to believe that these problems can be worked out in advance, when standards are first set, but that does not appear to be the case.

Environmental standards tend to be site- and industry-specific. Moreover, many uncertainties exist that preclude firm predictions, as Thompson has pointed out. There is room for both negotiation and for court enforcement in compliance policy, a fact that seems to be obscured when people debate the issue of negotiation and enforcement in principle.

The Due Diligence Defence

One of the most important cases to be decided in the field of environmental law in recent years is R v Sault Ste Marie (15), a 1978 decision of the Supreme Court of Canada. Some theoretical background is necessary to understand the case. Before this decision, it had been thought that offences fell into two categories with respect to the so-called mental element, or mens rea, that must be proven. The first was the traditional criminal law standard. It required the Crown to prove that the accused had a guilty mind, that is, that the criminal act was intended. The second category included various regulatory and public welfare offences. For this category the Crown did not have to prove any intentional element. The justification for this position lay in the importance of maintaining a high standard with respect to matters of health and safety. Courts reasoned that legislatures intended to control negligent as well as intentional conduct. Since these were generally regulatory matters the courts did not think it essential to require the traditional proof of a guilty mind that was the hallmark of the criminal law. It was generally believed that environmental offences fell into this second category, and therefore did not require any proof of mens rea.

What the Supreme Court did in Sault Ste Marie was to create another category midway between the other two. These offences are called "strict liability" offences, and, while the Crown does not need to establish any mental element, it is open to the accused to establish that he took reasonable care to avoid any violation, in which case he is not guilty of an offence. This has come to be known as the due diligence defence.

Sault Ste Marie is also important to environmental law for another reason. The offence in that case was one of the most common environmental offences - permitting or causing the discharge of materials that may impair water quality. Thus, the case also establishes that the common form of

environmental offence falls in the strict liability category, and therefore that due diligence is a valid defence.

In practical terms, this means that a discharger who violates the terms of his licence or permit may be able to defend against enforcement attempts by establishing that he acted with "due diligence". Thus, for example, the fact that equipment did not perform according to design specifications might be a valid defence to a charge based on non-compliance with environmental standards. By ordering and installing the equipment, the discharger did the best he could - he exercised reasonable care.

This interpretation is inconsistent with the theory of a permit or licence. In theory, when the government gives a permit or licence to a firm it is saying essentially, "You can go ahead and operate as long as you do not violate the terms and conditions that are attached." It is inconsistent to allow the terms and conditions to be negated by the defence of due diligence, but that seems to be the state of the law at the moment.

In a recent paper, one prosecutor outlined the difficulties that are created by the due diligence defence. He stated:

Pollution inspectors trained to take samples of toxic materials and trace a pollution trail to its source, will now also have to establish who gave the orders that led to the pollution, who carried them out, what supervision was provided, how the equipment was maintained, and many other matters...(16).

His point was that the due diligence defence is easy for the accused to establish and hard for the Crown to refute. Prosecutors must now be prepared to respond to the defence of due diligence. To do this, he argues, they will have to inquire into the internal operation of the discharger, rather than just measure and deal with the discharge. He believes that this makes the prosecutor's job more difficult, perhaps even impossible.

The Fraser River Task Force also drew attention to the due diligence defence. Their point was that negotiations between the discharger and the government could assist the discharger in establishing due diligence. They stated:

Enforcement of permits and orders was lacking on many occasions and this proved to be a serious problem when the Task Force came to investigate the company. Although the company would be in violation of a permit for, in some cases, two or three years, no legal action had taken place by [the] Waste Management Branch. This resulted in almost tacit approval by the Branch and caused problems for the Task Force when it came time for the decision to lay charges because of the "due diligence" rule(7).

In strictly legal terms the due diligence rule does not go this far(17). But in practical terms it does appear to inhibit prosecutors and enforcement officials significantly. The problem can be dealt with in several ways. First, enforcement officials can create task forces of the kind now used in both British Columbia and Ontario and can train them to deal with the due diligence defence. Crown prosecutors may also require special training. This is not as hopeless a task as it may seem. It should be remembered that the accused has the burden of establishing due diligence. It seems unlikely that courts will long tolerate trumped-up excuses. The existence of prolonged negotiations between the polluter and the government over what should be done does not sound like a particularly persuasive defence, for example. In fact Ontario Environment Ministry legal staff suggested that negotiation that produces Ministry schedules of requirements may have the effect of defeating due diligence defences in any resulting prosecutions. How can a company be said to act with due diligence if it fails to comply with requirements which it in effect agreed to as a result of a course of negotiations?

In order to meet due diligence defences, prosecutors will have to present evidence concerning the techniques the company should have used to prevent the discharge. This would have the side benefit of educating everybody involved concerning the company's responsibilities. Moreover, this is really information that the prosecutor should have in any event for the purpose of sentencing. It may be true that fault or culpability should have nothing to do with whether a discharger is guilty of violating an environmental standard; however, it will usually be relevant to the size of the sanction. In order to persuade a judge to impose a large fine the prosecutor will usually have to establish that the polluter was culpable in some sense.

The second way of dealing with due diligence requires legislation. Environmental statutes may be amended to remove the defence. The Supreme Court in Sault Ste Marie was speaking

of the presumptions that should be used when the legislation is not clear about the presence or absence of a mental element in the offence. It is thus open to the legislature to specify that due diligence is not a defence to the charge of violating an environmental standard.

These two alternatives are not the only ones that might be considered. Swaigen, for example, suggests that ways might be found of easing the Crown's burdens without doing away with the due diligence defence(16). A discussion of these suggestions would carry us well beyond the scope of this report. We will therefore close this section with the observations that the due diligence defence does appear to make enforcement of environmental standards more difficult than it was, and that enforcement officials must develop a clear strategy for dealing with it, whether that be in the form of revised investigatory procedures or legislative amendment.

The Task Force Approach

Both Ontario and British Columbia have found it useful to create special agencies for enforcement of environmental legislation. We have already referred to the British Columbia Task Force Study, written in 1980(7). The original Task Force recommended the creation of a permanent Task Force. It identified several benefits to the task force approach. First, the task force had been able to uncover numerous illegal discharges. Second, it was possible for the task force to coordinate its efforts with one Crown Counsel, which proved beneficial both in preparation and conduct of the cases. Third, the task force was able to maintain contact with various media and citizen groups, and this resulted in greater public awareness of the problems in the river. One result was an increase in reporting of violations by citizens. In fact, the Task Force reported that informants supplied them with reliable information that resulted in major investigations.

The Task Force also recommended that a special training program be instituted for Ministry employees who would be involved in enforcement. It was suggested that the program cover such topics as sampling procedures, the handling of evidence, basic enforcement techniques, the giving of evidence in court, and other similar topics. Indeed, one of the main benefits of the task force approach may be the opportunities it provides for specialized training. These opportunities also extend to Crown Counsel. If a stable task force is performing all of the investigations and the same Crown Counsel is used for prosecutions there is an opportunity for Counsel to instruct

the task force members in any areas where evidentiary difficulties are occurring.

One issue that is raised by the task force approach is the degree of separation that is desirable between those negotiating with dischargers with respect to the terms of permits and those who will enforce the legislation. Obviously, government officials in Ontario and British Columbia have reached the conclusion that some separation is desirable. Alberta officials pointed out that their departmental organization produces such a separation. The question is, how much separation is desirable? Should the enforcement team discuss cases under investigation with government officials involved in the granting of licences or permits? Or should the relationship be one of arm's distance?

Those who argue for a separation of functions between enforcement and licencing personnel believe that the two functions are incompatible. They believe that some degree of trust and cooperation must be maintained for effective negotiations. If the same personnel carry on both negotiations and enforcement activities, the spirit of cooperation essential to effective negotiations may be compromised. On the other hand, an individual who has been deeply involved in negotiations with a discharger may find it difficult to approach enforcement problems in an unbiased way. If both functions are carried on by the same personnel, both may be impaired.

On the other hand, strict separation of functions would clearly lead to serious duplication. Enforcement officials will inevitably need to have access to considerable engineering expertise of the kind found in the permitting authority. If they could not consult closely with their colleagues it would be necessary to provide significant additional manpower. This seems undesirable and unnecessary. Indeed, the Fraser River Task Force reported that it received excellent cooperation from the other government agencies involved, and that its operations were not hampered in any way by the contact. It seems reasonable to conclude that the question is one of balance. It should be remembered that too close a relationship between permitting and enforcement may impair both functions, but at the same time a cooperative spirit between the two government agencies must be fostered. The Fraser River experience seems to show that an appropriate balance can be achieved.

Adequacy of Fines and Sanctions

The adequacy of fines is an issue that was referred to by several officials we interviewed. They said that they frequently encountered cases where it was hardly worth prosecuting, despite a clear violation, because the fine imposed was likely to be too low to justify the effort. This same point has been made by commentators. Rankin and Finkle, for example, point out that there have been very few prosecutions under the British Columbia Pollution Control Act (13). They explain, "There is a reluctance on the part of Crown attorneys to prosecute and, if prosecuted, fines are generally trivial, representing no real deterrence." Victor, et al, reports similar findings for Ontario (14). We were told by one Crown prosecutor that it is better to prosecute under the federal Fisheries Act than the provincial Pollution Control Act because higher fines are likely to be imposed.

Fines may be low, sometimes frustratingly so. But does it follow that they represent "no real deterrence"? It seems unlikely that most corporate managers like to think of themselves as criminals. Might the criminal sanction have a real impact on the behavior of a corporation despite the fact that fines are low in comparison to potential abatement costs? Unfortunately, there are no empirical data on which one may base a judgment with respect to this issue. The issue is one that should be studied. In the meantime, government officials will have to continue to monitor the situation and revise the legislation on the basis of their best view of the adequacy of the fines being imposed. It is encouraging to note that recently courts have shown an increased willingness to impose large fines in pollution cases.

Another concern expressed about prosecutions is delay. Enforcement officials in all study jurisdictions expressed concern that the cost of some prosecutions, in which accused resorted to complex procedural manoeuvres, in terms of staff time and general upset in the agency, outweighed any deterrent effect. One official complained that one prosecution essentially occupied his entire branch for nearly six months. The problem was that the prosecution raised the issue to the political level. The Minister was pressured and in turn pressed the department to be thorough and aggressive. Another problem in protracted prosecutions is that negotiations cease and little or no abatement progress is likely to be made until the case is decided finally.

The Role of the Public

For the most part, the enforcement process is not accessible to the public. Permits may be public documents, but they may be hard to find and the right to copy them is sometimes denied. Monitoring data may also be accessible, in the sense that permission may be given to access it in an appropriate case. But monitoring data from particular dischargers may not be readily available. After an investigation has been started officials will be very reluctant to discuss the matter with anyone because they fear they may prejudice the case by discussing it. Once the matter is placed before the courts it is said to be "sub judice" and is thought to be beyond comment. It is therefore very difficult for an individual to get any information about either a particular case or about the enforcement process in general.

Lack of information about the enforcement process can easily cause a lack of faith in the process. It becomes easy to believe that the laws are not being enforced, that government and industry are conspiring to avoid enforcement of environmental standards. Unfortunately, it is hard for government to combat this tendency. There are obvious reasons why officials would be reluctant to talk about a pending investigation, for example. And monitoring data are hard to understand in the best of circumstances, and harder still to make available.

One illustration involves Alberta's practices. Alberta commendably makes its monitoring data available to the public and the press. It also incorporates the ambient air standards into each licence. Occasionally, due to unique weather conditions, the ambient standards are violated, despite the fact that emissions are within permitted limits. It should be noted here that the ambient standards are intended to indicate normal expectations. Standards cannot be based on the worst case because it is likely to be impossible to determine an "absolute worst case". All cases are possible, though the more extreme the event the smaller the probability or frequency of occurrence. Statements about atmospheric behavior can only be statistical(18). Therefore some element of risk is involved in all ambient standards. It is to be expected that unusual conditions may cause contaminant concentrations higher than those expressed in the ambient standards. The press and the public often wonder why no prosecution results.

This problem with ambient standards is addressed by the Alberta policy of permitting dischargers to "disclaim" ambient

violations where they can show that the violations are not due to their operations. If reasons for disclaimer are accepted by Alberta Environment then the disclaimed violations are not counted in the discharger's monthly report summary (21) .

Provided it is clear that such "excursions" pose no long- or short-term environmental hazard, there are various solutions to this problem. One might, for example, express the ambient concentrations as longer time averages, or one might allow concentrations higher than the standard on a specified number of days. Another solution would be to refrain from incorporating the ambient standard in the licence in the first place. The more general point is simply that it is often difficult to portray an accurate picture of the enforcement process.

Nevertheless, it is worthwhile trying to inform the public. An important step in Ontario's pollution abatement process (19) is the requirement that the company or person responsible for a severe and long-standing pollution problem prepare a report outlining technical options available for correcting the problem. The Ministry of the Environment then prepares a written review and both reports are made public subject to the confidentiality of proprietary information. An information session is then held by the Director where the problem is considered to be significant or where high public interest is generated. In other cases written comments from the public may be received.

In British Columbia the Fraser River Task Force recommended that the Ministry "embark on a program to encourage the public to report pollution violations" (7). The Task Force felt that the violation rate would drop if companies were aware of public participation in reporting violations. Its report also notes that the public had made valuable contributions to its investigations by bringing potential violations to its attention. We would add one further point: the more enforcement can be made visible and understandable to the public, the more faith the public will have in government's efforts to control pollution.

The Unsuitability of the Criminal Law Model

Many of the problems discussed above are symptomatic of a larger problem - the unsuitability of the criminal law model for the implementation of environmental standards. When lawyers think about criminal sanctions they usually think in terms of a uniform standard of conduct that can be applied

to all. It is assumed that certain conduct is prohibited, and that violation of the standard involves some degree of culpability. Because of the stigma attached to criminal convictions, the law requires a high standard of proof before a conviction can be entered. Moreover, some element of fault on the part of the accused is generally required, usually in the form of a guilty mind, or mens rea. All this is to protect the individual from any risk of being wrongfully stigmatized by a criminal conviction when he is not at fault.

The standards of conduct that are enforced by criminal sanctions normally apply to all equally. However, environmental standards do not. While ambient standards are intended to be general in scope, they usually can't be applied to individual dischargers. Consequently, specific discharge standards are developed for each discharge. These may be contained in a permit or licence. More importantly, they are usually negotiated to some extent(12). None of this fits very well with the criminal law model. Criminal standards are not negotiated separately. They are not individually tailored to specific situations.

Other inconsistencies may be observed. The criminal model places a great deal of importance on the concept of fault or culpability. When we consider the case of a discharge that is impairing the environment does it matter whether or not the discharger is at fault? It may be that the discharger has acted impeccably throughout, but that some element of its discharge is discovered to have deleterious effects. The fact is that something must be done - that the discharge must be cleaned up. Fault is irrelevant.

The criminal model also requires the Crown to carry a high burden of proof, in order to avoid convicting individuals who may be innocent. Does the same policy apply in the area of pollution control? Recall the case in which the court rejected the calculation of an average concentration from several readings because that did not satisfy the criminal law burden of proof(11). Should it matter that the measurements are approximations, subject to some doubt? If they are reasonable measurements, from an engineering point of view, why shouldn't they be relied upon? Companies accept the risk of inaccurate measurements in other areas of their activities, why not with respect to the measurements of their discharge? In fact, why shouldn't we say to the discharger, "if you want more accurate measurements, buy better equipment. Don't try to avoid the penalty for non-compliance by saying the measurements aren't good enough."

It might be more appropriate to regard the permit or licence as a kind of contract(20). This is more consistent with the fact that permit standards are often based on negotiations. It would also avoid the problems posed by the due diligence defence and the high standard of proof required in criminal proceedings. It is not possible, at this time, to evaluate this approach but it probably merits further study. One would have to study the concepts of contract law closely to determine whether they are consistent with the needs of environmental law. One would also have to resolve questions about the role of the public in the negotiation process. Even then, the criminal sanction would clearly have some role to play, for example, with respect to firms that intentionally dump toxic chemicals or discharge without a licence. All that can be said at the moment is that the criminal process does not seem to fit the needs of environmental law.

This may account for the fact that all provincial enforcement officers interviewed placed principal emphasis on control order-type processes. Saskatchewan legislation does not include control order powers. Officials there would like to have such powers, and amendments are under consideration. In the meantime much the same effect is achieved by limiting permit terms to one year or sometimes even less.

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